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(54) **RESTRAINING DENSE PACKAGING SYSTEM FOR LCD GLASS SHEETS**

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(57) **ABSTRACT**

A reusable dense packaging system used to transport large size display substrates, is provided made up of three main components; a pallet frame, a cover, and restraining means. The restraining means securely hold the glass sheets within the cover and on the pallet frame. Restraining means includes one or more retaining bars moving towards and away from the front of the glass sheets and a mechanical system. The mechanical system may include the use of a pressing panel, a belt apparatus, a scissor-like mechanism, positioning devices, or a retaining bar pulling system, each capable of moving towards and away from the front of the glass sheets. Each embodiment allows for packaging from 1 to N glass sheets with flexibility and stability and with manual or automatic operation.

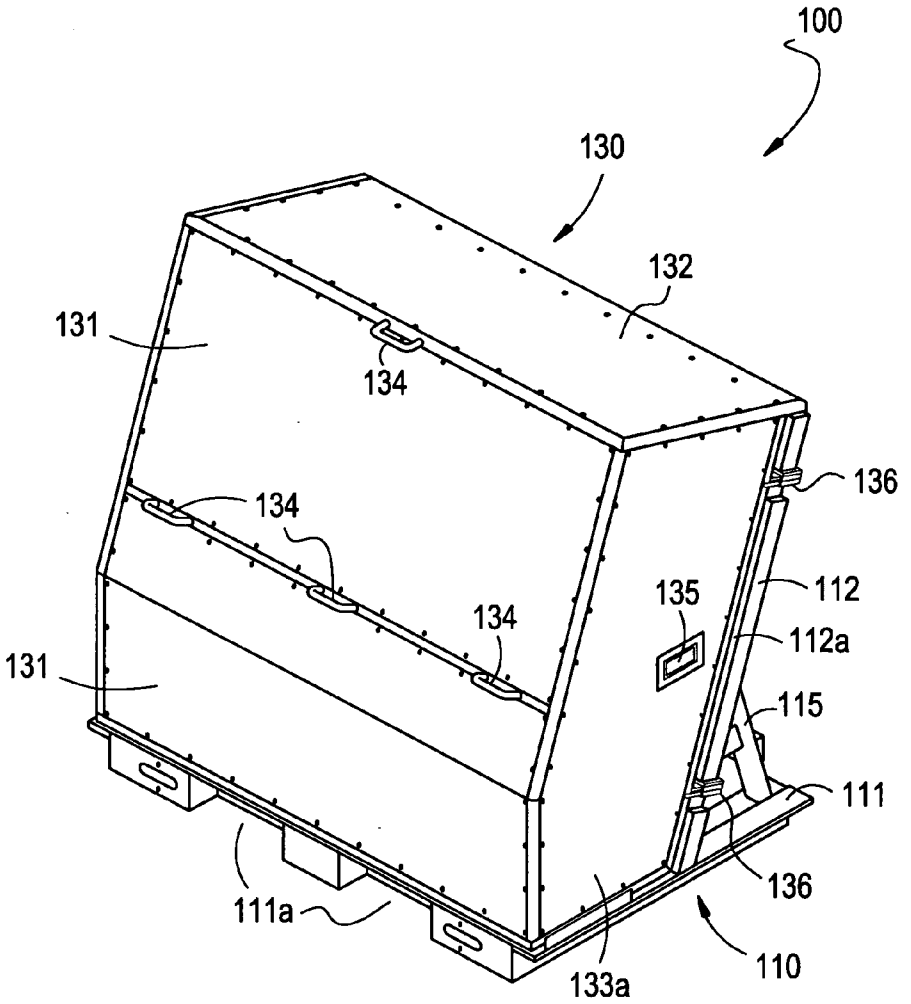
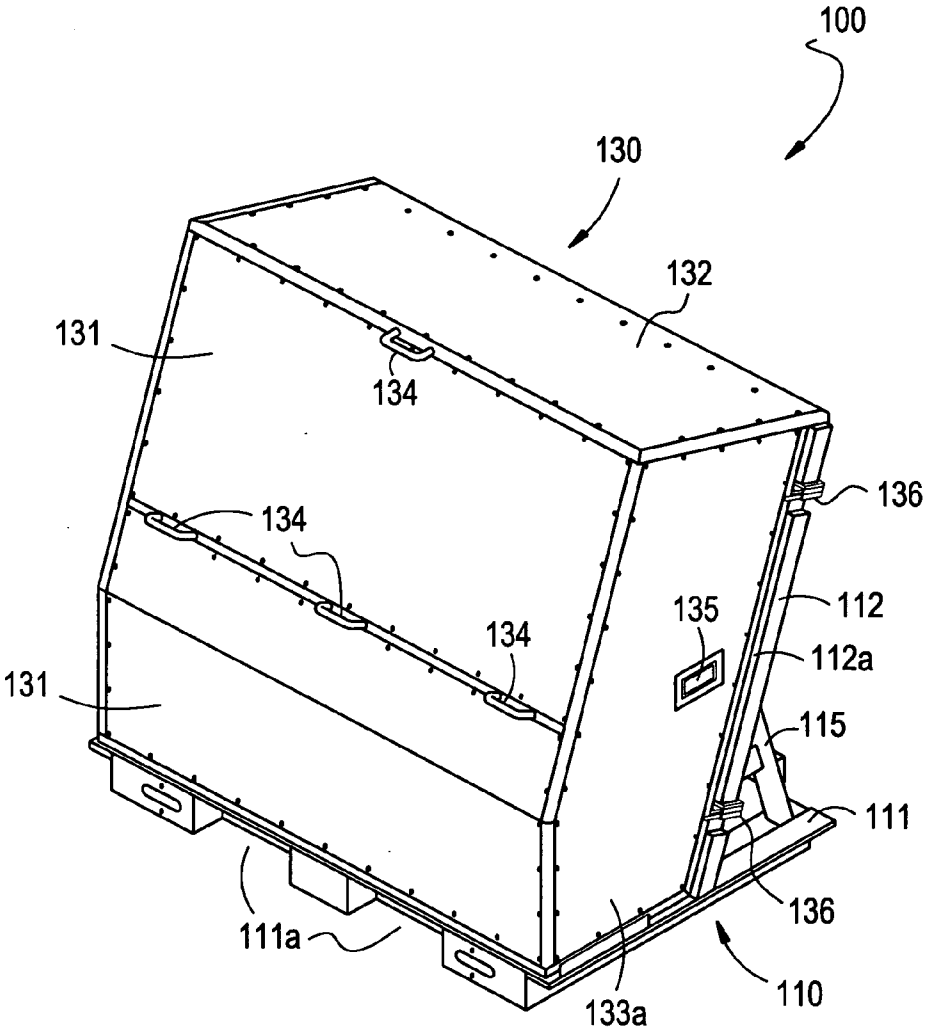


FIG. 1


100
130
132
131
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136
134
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112
134
112a
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115
111
136
111a
110
133a

FIG. 2

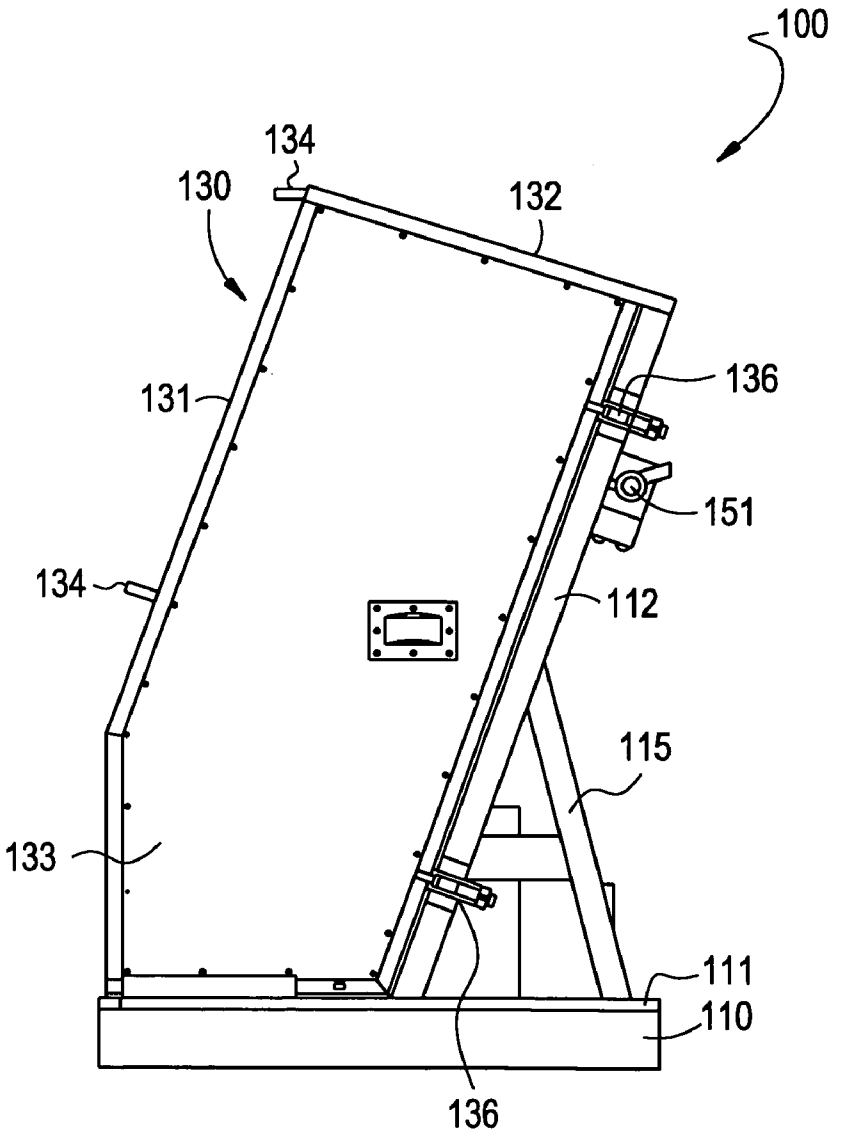


FIG. 3

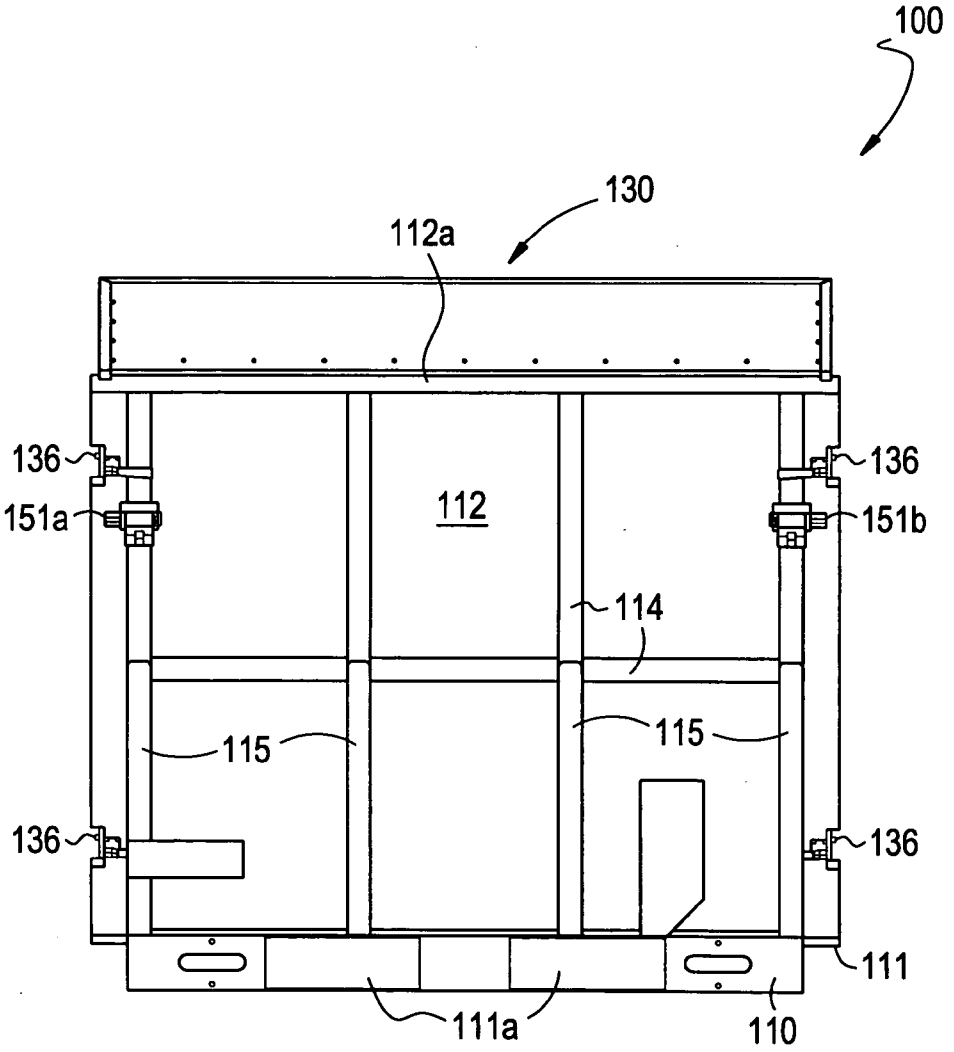

100
130
112a
136
151a
112
151b
136
114
115
115
136
136
111
111a
110

FIG. 4

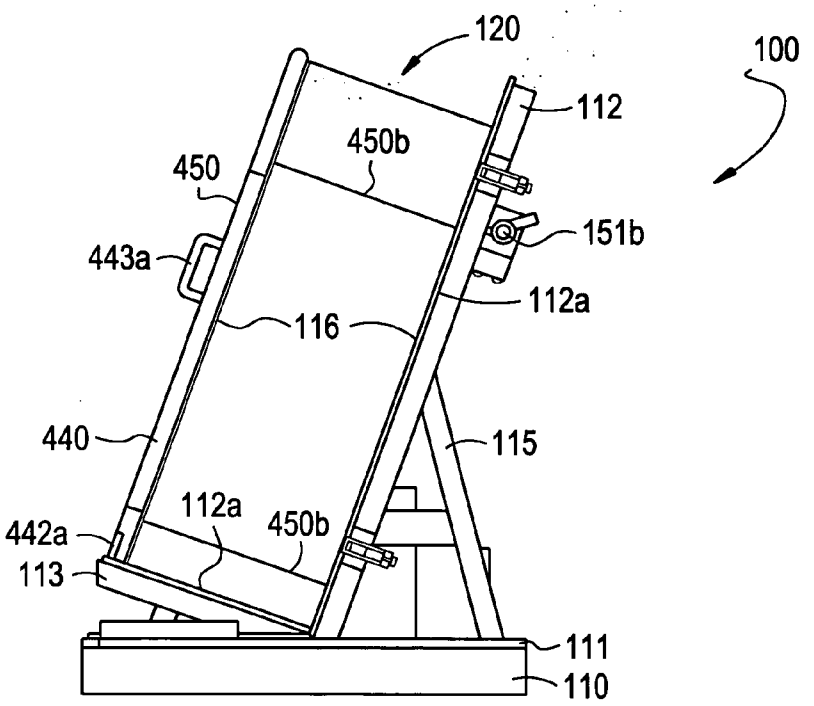

120
100
112
450b
450
151b
443a
112a
116
440
115
112a
450b
442a
113
111
110

FIG. 5

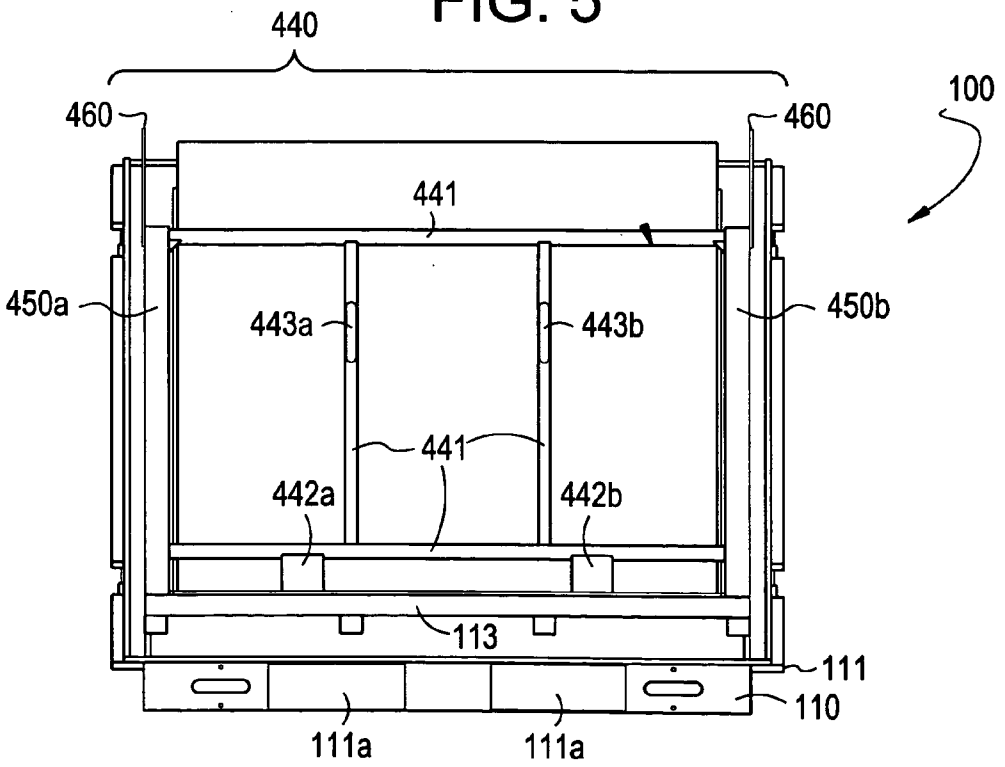

440
460
460
100
441
450a
443a
443b
450b
441
442a
442b
113
111
110
111a
111a

FIG. 6

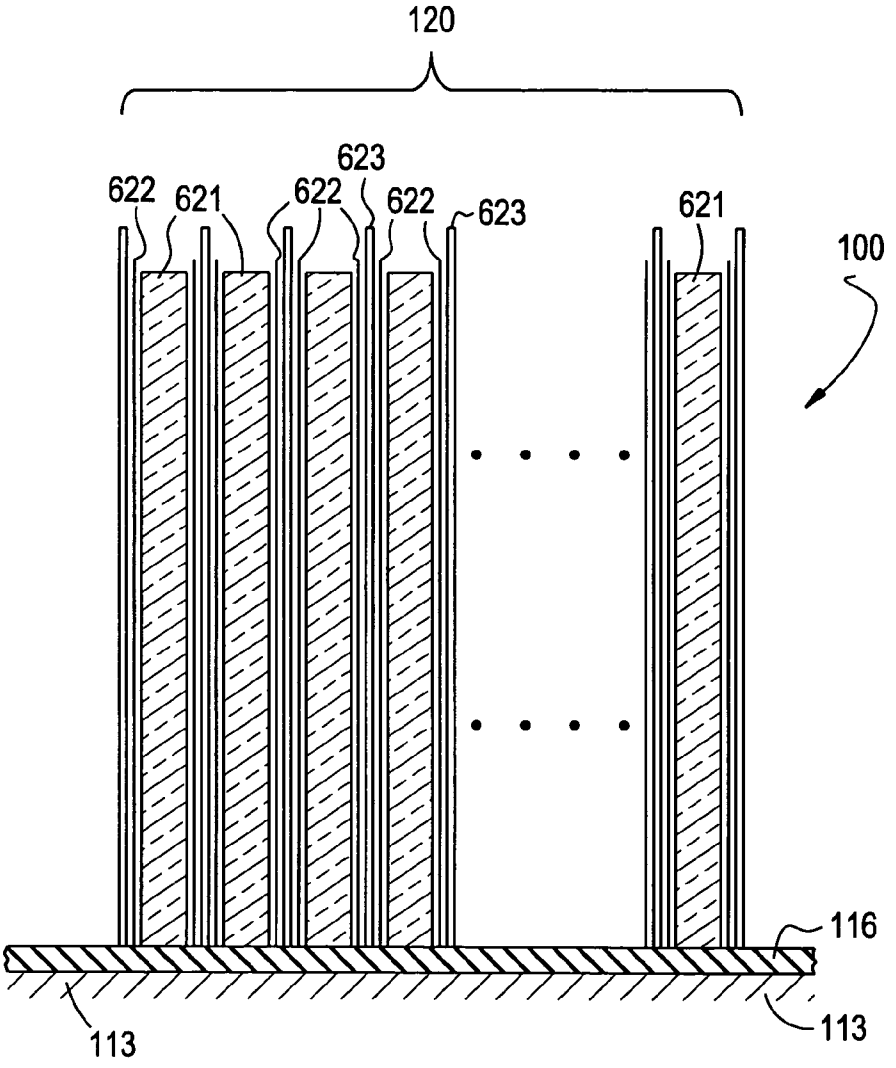


FIG. 7

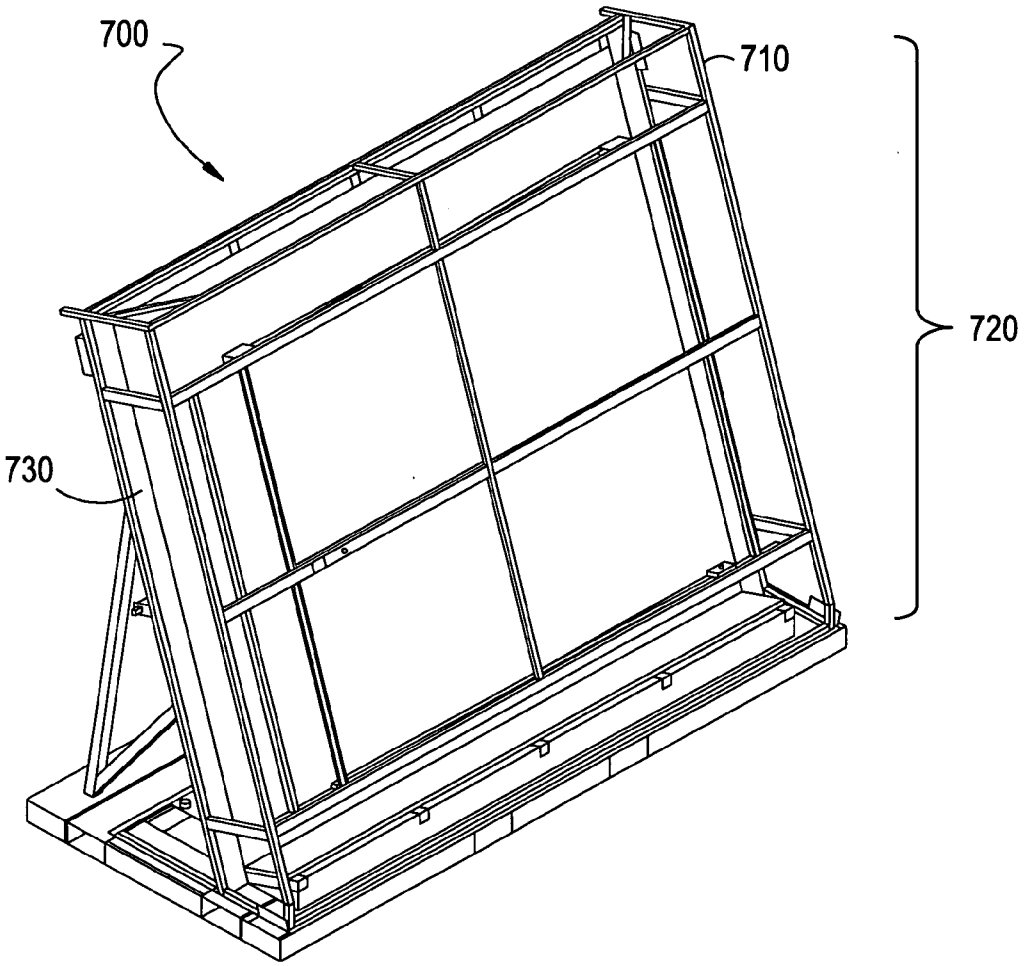


FIG. 8

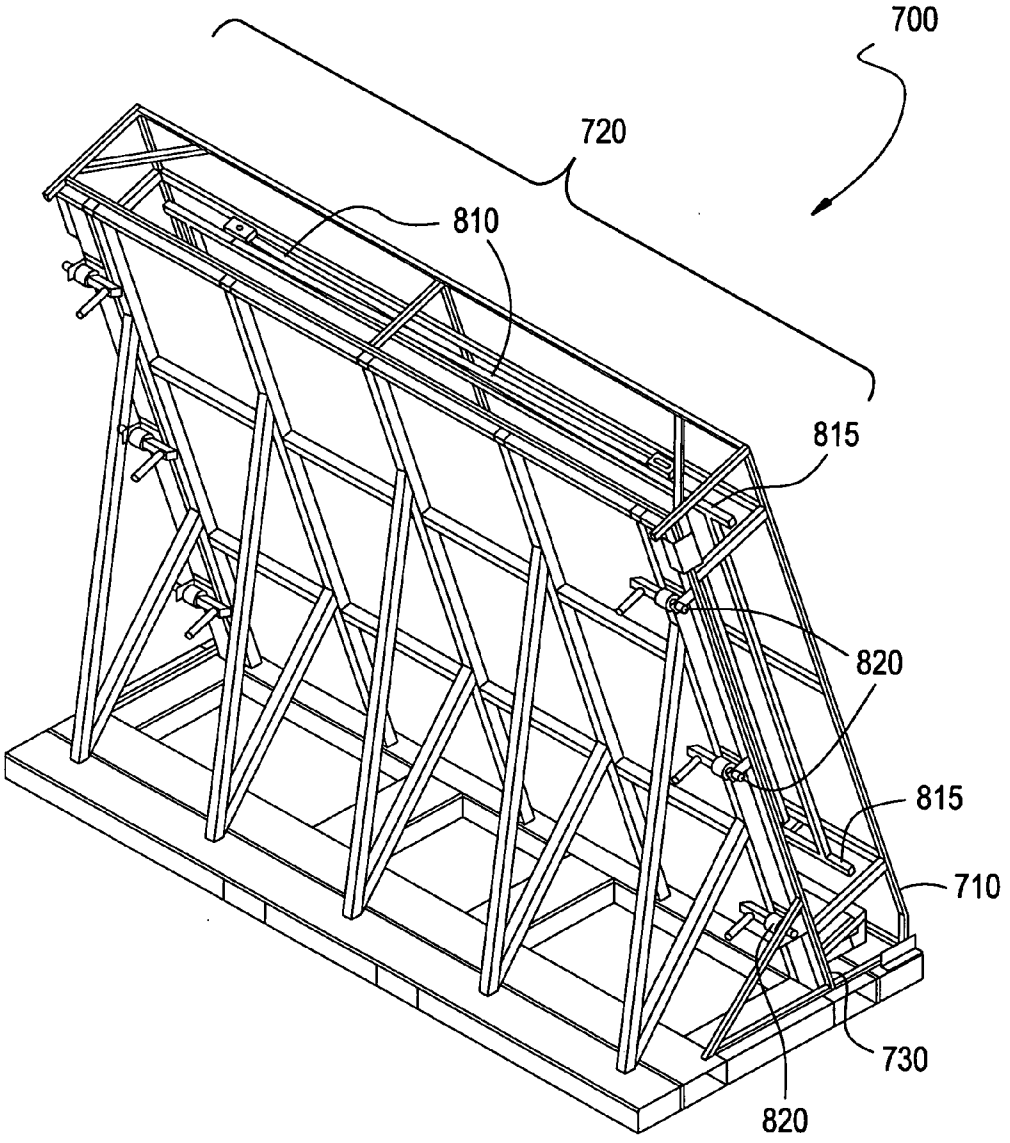


FIG. 9

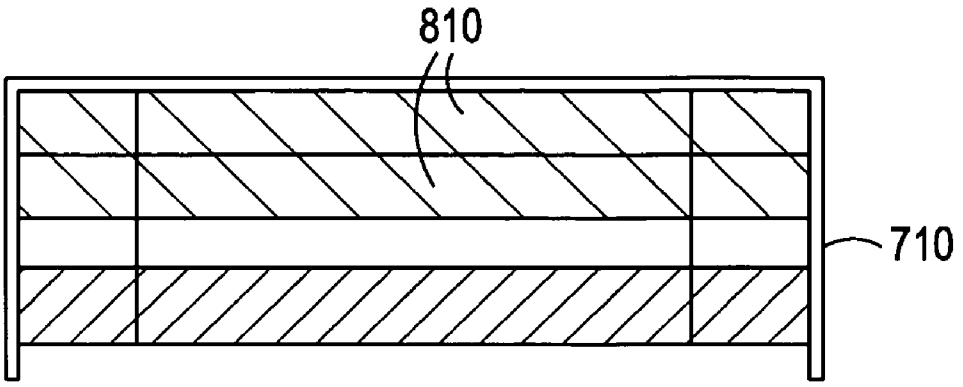


FIG. 10

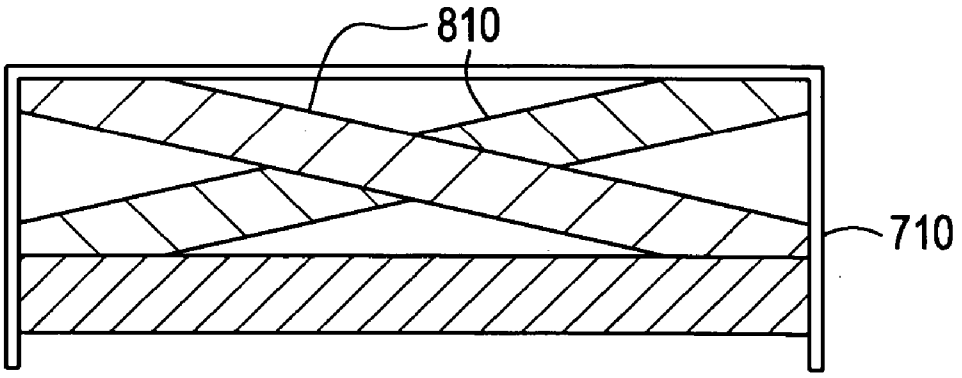
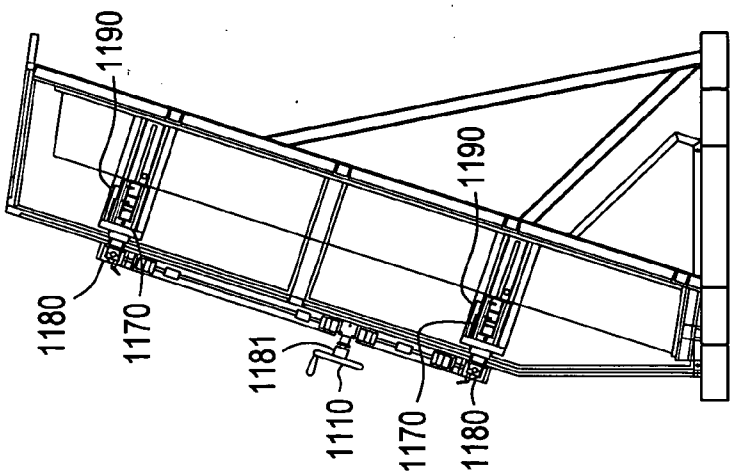


FIG. 12


1190
1190
1180
1170
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1110
1170
1180

FIG. 11

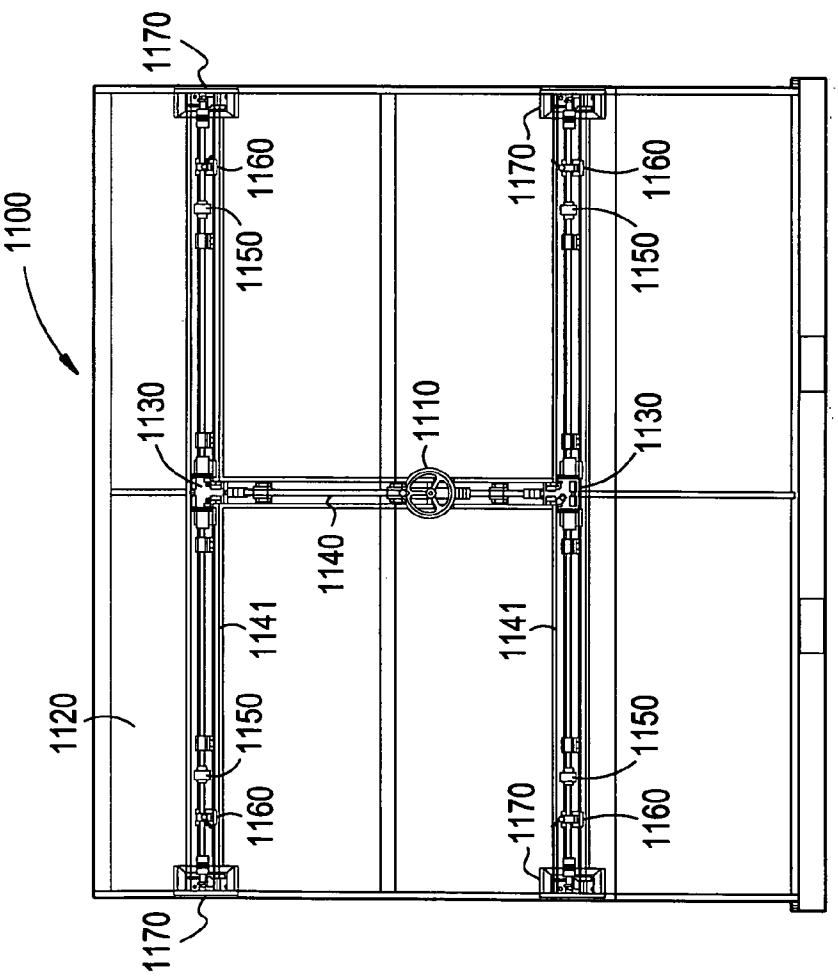
1100
1170
1160
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FIG. 13

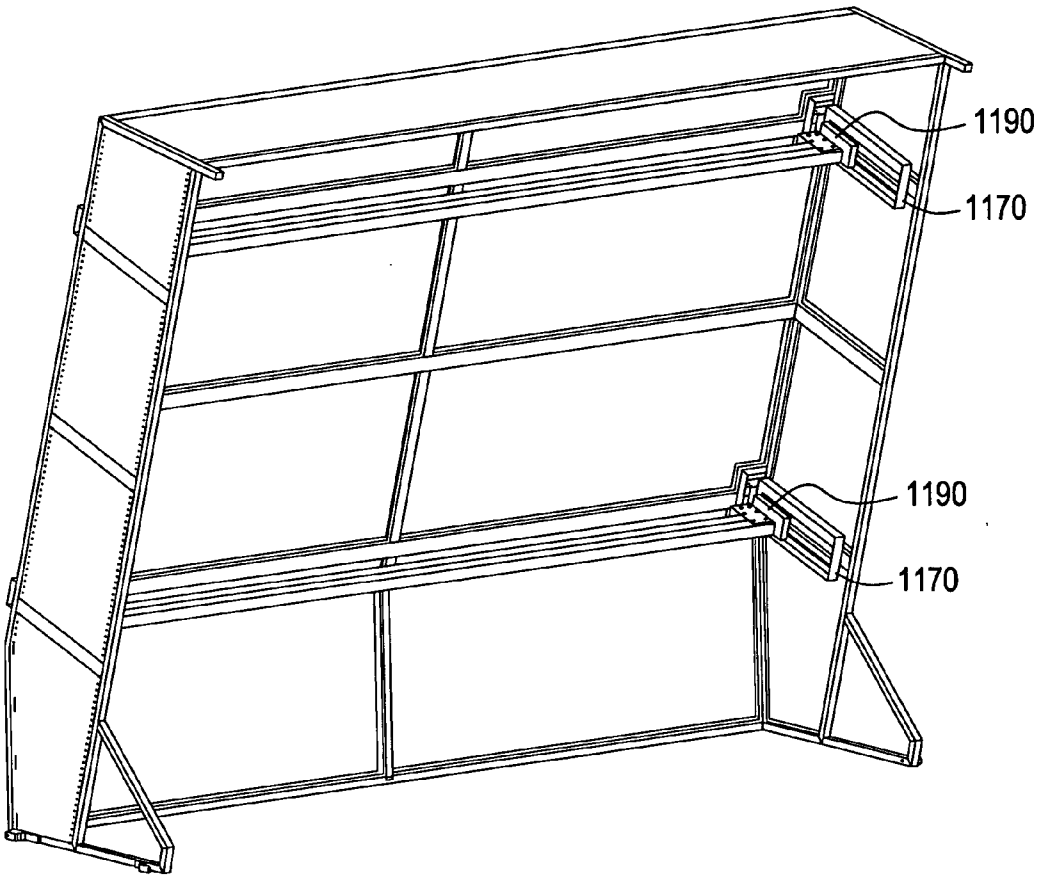


FIG. 14

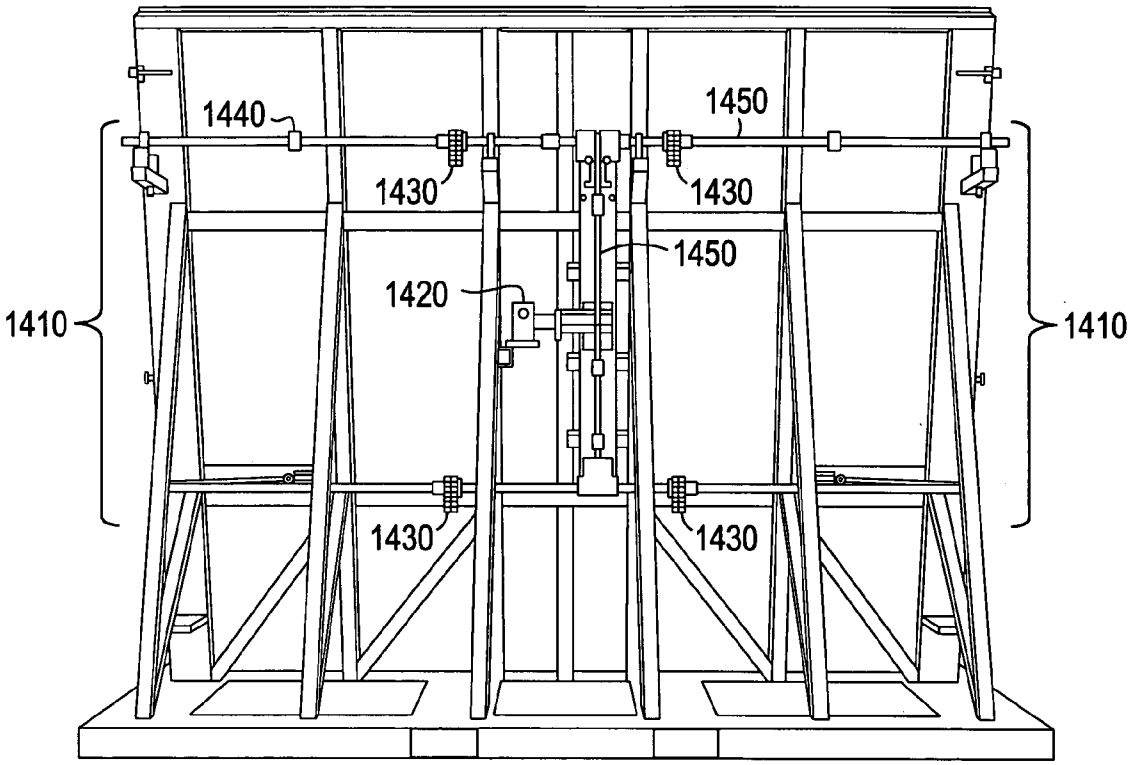


FIG. 15

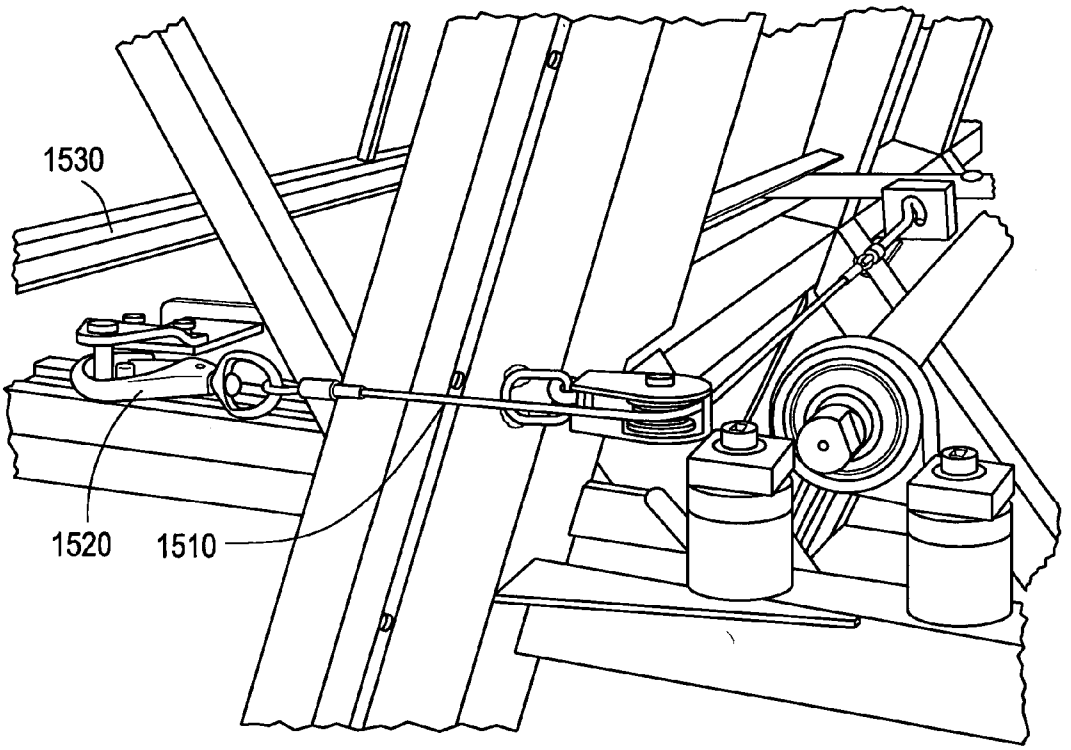


FIG. 16

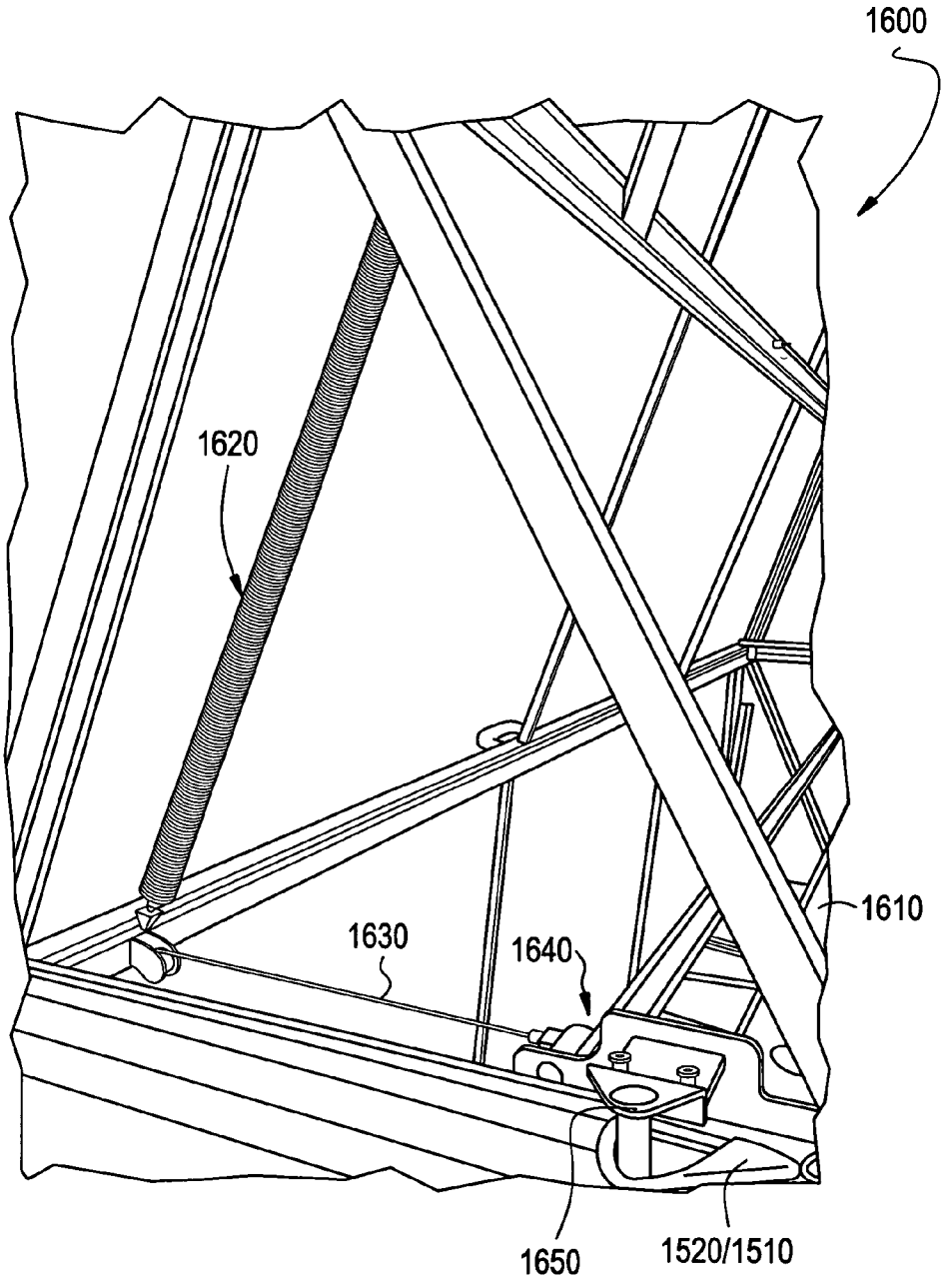
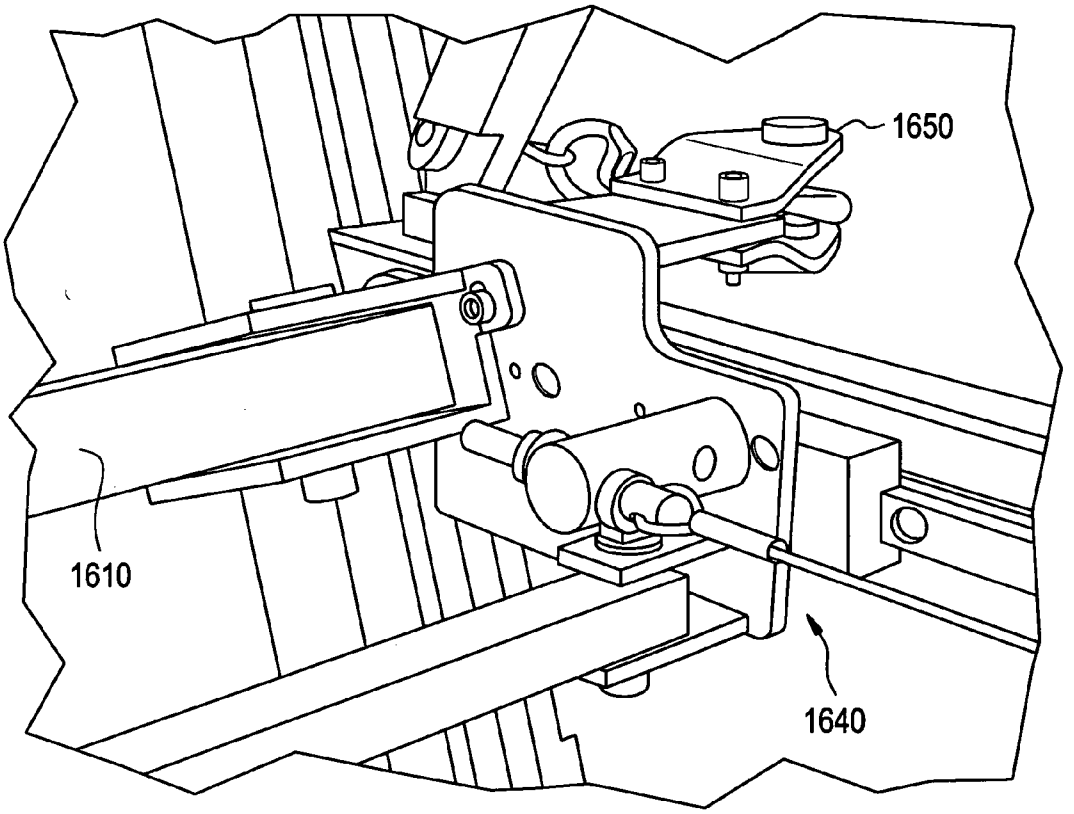


FIG. 17



RESTRAINING DENSE PACKAGING SYSTEM FOR LCD GLASS SHEETS

BACKGROUND OF THE INVENTION

[0001] 1. FIELD OF THE INVENTION

[0002] The present invention relates generally to packaging, and particularly to packaging for large size display substrates, such as a stack of glass sheets.

[0003] 2. TECHNICAL BACKGROUND

[0004] In recent years, glass substrates for Liquid Crystal Display (LCD) panels have increased in size, along with enlargement of Liquid Crystal Display panel sizes.

[0005] Conventional non-contact packaging, such as PP-case and L-supporter, has dominated the market as the delivery model for smaller size glass substrates, such as Gen 4, 730 mm×920 mm, or smaller. Recognizing limitations in packing density, their requirements for significant storage space, and the difficulty to extend their application to ever-increasing sizes, these conventional non-contact or spacer type packages have effectively reached a practical limitation for glass sizes greater than or equal to Generation 5.

[0006] Pursuant to the trend for larger and larger substrates sizes for Liquid Crystal Display comes the need for suitable packaging for the transfer of large glass sheets to and from the Glass manufacturers to the Display manufacturers or in essence, but not limited to, the providers of Thin Film Transistor panels and/or the Color Filter panels.

[0007] In some prior art approaches, when glass sheets are transported, for example, to a Liquid Crystal Display manufacturing plant, to a Thin Film Transistor (TFT) manufacturer or to a Color Filter (CF) maker, the glass sheets are typically placed in a crate or a square box with removable side panels at a glass sheet manufacturing plant typically with protective plastic films or other separating materials being disposed on either side of each glass sheet before transportation. When containers of these types are used, however, the size of glass sheets to be transported is limited. Further, these containers, though adequate enough in delivery, is poor in mechanical strength. For these reasons, in the prior art, high density safe transportation of large glass sheets could be improved. In addition, the glass sheets are undesirably susceptible to contamination during transportation, since the crates or boxes are also poor in weatherability, often requiring over-pack (e.g. a box within a box). In the Liquid Crystal Panel manufacturing plant, the delivered glass sheets are manufactured into substrates for liquid crystal panels, after uncrating the glass sheets, removing the protective films or separating materials disposed on either side of each glass sheet, and cleaning the glass sheets. Further, there is a problem in that a cleaning process for removing adherents, such as a residual adhesive remaining on the glass sheet after removing the adhesive protective films and contaminants which are attached on the glass sheets in the course of the transportation, typically takes a long time. It should be noted that even some non-adhesive materials, such as polyethylene or polymeric films, if used, may leave some residual organic materials which must also be washed off with a detergent or other like wash; however, these non-adhesive residuals are typically not as difficult to clean off or as time consuming as residuals left behind by adhesives.

[0008] Prior art approaches for performing the above described desired capabilities that are known in the art include, but are not limited to, the following examples.

[0009] Prior art Japanese Patent Application Number P2000-142856A, entitled Glass-Plate Storage Method, filed on Nov. 13, 1998 by Nippon Electric Glass Co. Ltd. and published on May 23, 2000 provides a glass-plate storage method for high storage efficiency for storing a plurality of glass plates is obtained through interposing interleaving papers in the spaces between, and essentially separating the glass-plate surfaces, thereby reducing the degree of contamination and marring of the glass-plate surface.

[0010] Also in the prior art, Japanese Patent Application No. 2000-203679, entitled Glass Panel Storage Method, filed on Nov. 12, 1999 by Nippon Electric Glass Co. Ltd. provides a glass panel storage method with which even when glass panels are used as the substrate material for flat display panels to be stored, separating members are interposed only at the surface edges of the glass panels. Thus, there is no contamination of the effective surface and storage efficiency is achieved.

[0011] Also in the prior art, U.S. Pat. No. 6,527,120 entitled "Containers for Packaging Glass Substrates", granted on Mar. 4, 2003 provides packaging for flexible LCD substrates where the containers include arc-shaped grooves which apply an elastic strain to the substrates reducing damage to the substrates during transport.

[0012] However, these and other existing prior art solutions still have several limitations. Firstly, there is limited protection of container contents from weather during transportation. Though these prior art containers in general are likely proven adequate for effectively meeting transportation testing specifications, the container coverings can "pool" with liquid and the container must be wrapped in plastic or covered over with other means in order to seal it from elements. Additionally, the disposing of these consumable items becomes an environmental and cost issue as well. Secondly, there is marginal mechanical strength of the container due to side-wall construction of corrugated plastic materials.

[0013] Where tilting is not required (for instance as in typical PP or L type prior art containers), loading glass sheets is complex due to precision of placement in slots. This type of vertical orientation of glass sheets when the container is in the "normal" or upright position also requires additional equipment to tilt the container for loading and unloading. Additionally, prior art PP or L type containers typically only hold about 20 sheets of glass requiring frequent change-out of containers. Further, the construction of mild steel with painted surfaces found also in the prior art is susceptible to chipping, flaking and particle generation, as well as corrosion, resulting in marginal clean room compatibility. Construction is also subject to deformation during normal warehouse handling.

[0014] In certain other prior art solutions, there is difficulty in handling containers on conveyors and truck beds due to limited contact area of a pallet base. Additionally, glass cushioning materials exhibit significant deformation over time, requiring periodic adjustment of packing and unloading robot controls, as well as periodic full replacement due to permanent deformation. Still further, in certain prior art

solutions, there is an inability to scale up for larger sizes of glass without material handling equipment (overhead lift) being involved. This would require two or more operators to handle assembly and disassembly. Still further, most of the prior art solutions, include multiple loose parts (some on the order of 10 or more pieces plus hardware) which though allow for collapsibility, are costly both to assemble and to maintain. One primary limitation of the prior art is that there is marginal retention of glass movement in container. The prior art methods to secure a stack of glass sheets and to avoid movement during transportation after it has been packed or shipped are not sufficient to retain the glass sheets from moving under all conditions such as transportation conditions of excessive vibration or shock; hence there is the potential for breakage to occur.

[0015] As becomes evident, the larger the glass sheets become, the fewer sheets can be packaged into a container. Thereby existing methods of packaging LCD glass seem to have met practical limitations in scaling beyond Gen 5 glass sheet size [approximately 1100 mm×1300 mm]. They carry an inherent penalty in space and logistics due to low sheet counts per container volume.

[0016] This stipulates the need for denser packaging, utilizing one or more layer of surface protection between glass sheets. For instance, the architectural and automotive glass industries have realized this need and have begun to use densely packed vertical boxes and tilted L-frames to ship glass substrate product. "Dense packs" are emerging as the future delivery model for Gen 5 glass sheet sizes as it is known in the art and larger, where Gen 5 can be supported by both the conventional packaging and dense packaging. Dense packaging has been proven as a viable delivery model, however, as substrate sizes become even larger, such as with Gen 7 and beyond, new challenges arise for dense packaging, particularly around size and weight of the container components, which become even more unwieldy for operators to handle, as well as transportation constraint issues, for instance, transporting containers through standard size doors, available sizes of shipping containers and standard trucks.

[0017] A new approach is needed that preferably overcomes the disadvantages of any of the prior art solutions above while still providing safe, high density and cost-effective transportation of large glass sheets and reduced time necessary for glass sheet cleaning process after transportation.

[0018] A new approach is also needed to address the difficulties arising from the ever increasing glass sheet and container size and the need for making such a container alternatively 'automation compatible' in both the LCD glass manufacturer's packaging operation as well as in the glass user's unpacking operation.

[0019] A new approach is needed that leverages features of a manual or automation compatible packaging system towards allowing for a fully automated container system when desired.

SUMMARY OF THE INVENTION

[0020] One aspect of the present invention includes a container for packaging and transporting one or more glass sheets where the container includes a frame having a pallet with a base, a cover secured to the pallet such that said one or more glass sheets is sealably covered therewith, a support panel and seat provided with cushioning members, and restraining means for controllably and adjustably retaining said one or more glass sheets with respect to the support panel of the pallet.

[0021] In one aspect of the invention is the restraining means further includes one or more retaining bars moving towards and away from the front of the one or more glass sheets and a mechanical system for moving said one or more retaining bars. In another aspect of the invention, the restraining means is preferably integrated into said cover. Further aspects of the restraining means include a pressing panel coupled with the retaining bars.

[0022] In another aspect of the invention, the mechanical system includes a plurality of belts and belt restraint devices. In still other aspects of the invention, restraining means further includes at least one scissor-like mechanical system coupled to the one or more retaining bars or a plurality of mechanical positioning devices coupled to the one or more retaining bars. In still another aspect of the invention, the mechanical system is integrated with the frame and includes a retaining bar pulling system. The inventive aspects of the restraining means can be operated manually or automatically. In another aspect of the invention, the cover is sealably affixed to the frame via a gasket seal.

[0023] In a further aspect of the invention, pressing panel is removable. In a yet further aspect of the invention, the retaining bars operate independently from each other. Still further aspects of the invention are that the frame and cover are made of a metal or other composite material.

[0024] In another aspect of the invention, the one or more glass sheets are stacked with no spacing in between. In a still further aspect of the invention, non-scratching interleaf materials are positioned between the glass sheets. In an additional aspect of the invention the interleaf materials further include non-adhesive plastic films attached on either side of each glass sheet and a paper sheet is disposed between each of the adjacent plastic films.

[0025] Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0026] It is to be understood that both the foregoing general description and the following detailed description present embodiments of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments of the invention and together with the description serve to explain the principles and operations of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The invention is further illustrated with reference to the following drawings in which:

[0028] FIG. **1** is a perspective view of the entire container configuration thereof in accordance with a preferred embodiment of the invention.

[0029] FIG. **2** is a side view of the container shown in FIG. **1**.

[0030] FIG. **3** is a rear view of the container shown in FIG. **1**.

[0031] FIG. **4** is a side view of the container shown in FIG. **1**, with a cover thereof being removed.

[0032] FIG. **5** is a front view of the container shown in FIG. **1**, with the cover thereof being removed.

[0033] FIG. **6** is a schematic cross-sectional view of a glass sheet stack in accordance with a preferred embodiment of the present invention.

[0034] FIG. **7** is a front view of a container with a restraint system integrated into the cover in accordance with a still further alternate preferred embodiment of the invention.

[0035] FIG. **8** is a back view of the configuration shown in FIG. **7** showing the container cover having an internal scissor restraint system.

[0036] FIG. **9** is a top view of the configuration in FIGS. **7** and **8** showing the unexpanded internal scissor restraint system.

[0037] FIG. **10** is a top view of the configuration in FIGS. **7** and **8** showing the expanded internal scissor restraint system.

[0038] FIG. **11** is a front view of the container with a retaining bar integrated into the cover in accordance with a still further preferred embodiment of the invention.

[0039] FIG. **12** is a side view of the configuration in FIG. **11**.

[0040] FIG. **13** is a rear view of the configuration in FIG. **11**.

[0041] FIG. **14** is a rear view of the container with a retaining bar integrated into the cover in accordance with a still yet further preferred embodiment of the invention.

[0042] FIG. **15** is a side view of the configuration in FIG. **14**.

[0043] FIG. **16** is a side view of the configuration in FIG. **14** showing a preferred retraction mechanism.

[0044] FIG. **17** is an inside view of the configuration in FIG. **14** showing preferred attachment points.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0045] The present invention restraining packaging system overcomes prior art problems with a high-density packing system wherein glass can be easily packaged by a manufacturing company and unloaded with ease by customers while also reducing container space requirements by a factor of 10×-20× for an equivalent quantity of glass, as well as improving overall logistics due to the reduced numbers of containers required for an equivalent number of glass sheets. The invention also provides for controllable and repeatable retention of the glass suitable for a multiplicity of transportation environments.

[0046] As will be shown, dense packing of the LCD substrates allows substantially more glass to be packaged in a given container, requiring less container packages, and hence, less storage space for those packages. For example the typical spacing for prior art L-supporters is approximately 20 mm for a Gen 5 substrate (one container typically being capable of holding about 20 sheets of glass). Comparatively, a dense pack has substantially no spacing with only the thickness of the two layers of film and paper between the glass sheets, these thicknesses typically being less than 200 microns (0.2 mm).

[0047] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0048] FIGS. **1** to **5** show the general configuration of a container according to a first preferred embodiment of the present invention. FIG. **1** is a perspective view of the preferred container with the cover on; FIG. **2** is a side view; FIG. **3** is a rear view of the container. FIG. **4** is a side view of the container with a cover thereof being removed, and FIG. **5** is a front view of the container shown in FIG. **4**.

[0049] Referring now to FIGS. **1** to **5**, in accordance with a preferred embodiment of the present invention, a container which is designated generally throughout this specification by the reference numeral **100** includes a pallet **110** (preferably metal) which can be loaded on and lifted by a forklift truck, and a cover **130** preferably made of a laminated aluminum polymer composite, a metal, a high strength polymer or a metal/polymer laminate or other composite material to be positioned over a stack of glass sheets **120** supported on the pallet **110** such that a seal is produced in the container (see description infra with respect to FIG. **5**). The container preferably has no paint on it and as such, is not susceptible to flaking or chipping.

[0050] In accordance with a preferred embodiment of the invention, the weatherproof cover **130**, which sealingly covers the glass sheet stack **120** from the front thereof, is preferably constructed from an aluminum frame, such as square tubing or extrusions, and an aluminum composite panel, and formed in the shape of box that is open backward and downward using a front panel **131** which may include one or more sections, a top panel **132**, and side panels **133***a*, **133***b* (**133***a* shown). A plurality of handles **134** is provided on the front panel **131** and a handle **135**, such as a grip recess or recessed handle, is provided on each of the side panels **133***a*, **133***b*. The edges of the cover **130** are disposed in intimate contact with the corresponding portions of the pallet **110** and support panel **112** via a gasket seal **112***a*. The cover **130** is releasably mounted on the pallet **110** with a simple operation by means of clamping members **136**, which are provided, preferably two on each side of the support panel **112**, in a manner spaced along the rear edges of the side plates **133***a*, **133***b* and the opposite ends of the support panel **112**. The cover **130** preferably includes four wheels (not shown) at its bottom corners, one for each corner, such that mounting and dismounting of the cover **130** to and from a pallet **110** is facilitated. The wheels can either be internal or external to the cover **130**.

[0051] The pallet **110**, which is preferably made of a stainless steel material, includes a substantially flat bottom

base allowing for highly-flexible conveyance by conveyors employing rollers, chains, walking-beams, or like methods and including entry slots **111***a* which can receive a fork of a forklift truck from the front (shown) or from the rear or from any of the sides (not shown); a support panel **112**, inclined backward about **18** degrees or more as shown in FIG. **4** and secured on the pallet **110**; a bottom glass support seat **113** which is secured on the pallet **110**; and a cover sealing gasket **112***a* which is adhesively attached around the perimeter of the support panel **112** and the pallet **110** and cover support **111** as shown in FIG. **4**.

[**0052**] The container **100** provides many advantages such that the container is robust and durable for long-term use, and the container can be returned, cleaned and reused repeatedly.

[**0053**] FIG. **2** shows a side view of the container **100** of FIG. **1** with the cover **130** placed on the container in accordance with the preferred embodiment of the present invention. The side view of the container allows us to view additional structural elements. For instance, four posts **115** are provided (one shown in FIG. **2** and also shown in FIGS. **1** and **4**) so as to extend between the support panel **112** and the pallet **110**, whereby the support panel **112** is securely held on the pallet **110** while maintaining an inclined position. Alternative equally effective embodiments may include a different number of posts **115** in any number of different configurations as a matter of design choice by one of skill in the art. Additionally, a belt take-up type restraining device **151** is shown which will be discussed in detail infra with respect to FIGS. **4** and **5**.

[**0054**] FIG. **3** is a rear view of the container shown in FIG. **1** in accordance with the preferred embodiment of the present invention showing the configuration of the four posts **115** that extend between frame **114** of the support panel **112** and the cover support **111**. Four clamping members **136** are also shown in this view. Additionally, two restraining belt devices **151** are depicted in the rear view at the top part of the cover and will be discussed in further detail below.

[**0055**] Referring now to FIG. **4**, a side view of the container of the preferred embodiment of the present invention is shown with the cover **130** thereof removed to include cushioning members **116**, preferably made of EPDM rubber (a resilient elastomer based on ethylene-propylene-diene terpolymer) preferably with a hardness of about 60 on the Shore scale of hardness, are adhered on the support panel **112** and the seat **113** by means of a suitable adhesive. It should be noted that other forms of cushioning members, other hardnesses, other equally effective ways to cushion with or without the use of an adhesive, either using other polymer-like materials that exhibit similar properties or using foam or a laminated foam for instance are also further contemplated by alternative design embodiments to this invention. In a preferred embodiment, the glass sheet stack **120** is placed on the surface of the seat **113** via the cushioning member **116** and held in an inclined position by the pressing panel **440**.

[**0056**] As can be seen from FIGS. **4** and **5**, a removable pressing panel **440** preferably made of light weight aluminum and having thereon the cushioning member **116** is in contact with the front surface of the glass sheet stack **120** which is disposed in an inclined position on the seat **113** of the pallet **110** and the support panel **112**.

[**0057**] A pair of leg standoffs **442***a*, **442***b*, for supporting the pressing panel **440** on the seat **113**, is provided on the lower edge of a frame **441** (see FIG. **5**) fixed around and on the front side of the pressing panel **440**. Handles **443***a*, **443***b* (handle **443***a* is shown in FIG. **4** and both handles shown in FIG. **5**) are also provided on the frame **441**. Vertical posts **460** protect the glass sheets from breaking when removing the cover. Different sizes of glass sheets within a given Generation family are accommodated in container **100**. Pressing panel **440** preferably includes frame **441**, leg standoffs **442***a*, **442***b*, handles **443***a*, **443***b*, and vertical posts **460**.

[**0058**] The pressing panel **440** is restrained relative to the support panel **112** preferably by means of two belts **450***a* and **450***b*. More specifically, the belts **450***a*, **450***b* are attached to the lower part of the support panel **112**, one on each side of the support panel **112**. They then extend along the lower side surface of the glass sheet stack **120**, one on each side, in the frontward direction toward the pressing panel **440**, extending past the pressing panel **440** from the back side (the glass sheet stack **120** side) to the front side thereof, and then extending upwardly along the front surface of the pressing panel **440**. Subsequently, the belts **450***a*, **450***b* again wrap around to the back side of the pressing panel **440** and extend toward the support panel **112** along the upper side surface of the glass sheet stack **120**, one on each side, in the backward direction toward the support panel **112**. Finally, the belts **450***a*, **450***b* are releasably engaged on the back side of the support panel **112**, for example, preferably with winch-type belt take-up and tightening devices (belt restraining devices) **151***a*, **151***b* (**151***b* shown in FIG. **4**) which enable the adjustment of the tightness of the belts. These restraining devices provide adjustable and controllable means for retaining the glass sheets relative to the support panel of the pallet or a controllable tension over the glass sheets and the ability to tighten the restraint as needed. The belts are preferably made of a high strength polymer strap material, such as polyester, nylon, or the like. A different number of belts and restraint devices may be desired depending on design effectiveness and choice.

[**0059**] The pressing panel **440** is easily removed from the glass stack **120** by releasing the belts **450***a*, **450***b* from the winch-type tightening devices **151***a*, **151***b* in order to permit access to the glass.

[**0060**] FIG. **5** depicts other elements previously described of the front view of the container **100** with the cover **130** thereof removed and the pressing panel **440** in position.

[**0061**] In the cross-sectional view of the glass stack **120** depicted in FIG. **6**, an preferred embodiment of the present invention shows, but is not be limited to, the use of non-scratching interleaf materials positioned between the glass sheets, such as papers or hybrids of paper or polymer, non-adhesive or even adhesive types of materials.

[**0062**] It should be noted that FIG. **6** is depicted as having a vertical orientation only for the convenience of illustration purposes as typically the glass stack **120** is inclined when placed in container **100**.

[**0063**] Accordingly, in the preferred embodiment, the glass sheet stack **120** herein is shown to include a plurality of glass substrate or glass sheets **621**, which are arranged such that a surface of each glass sheet is parallel to that of the glass sheet adjacent thereto; non-adhesive plastic films

622, which are attached on either side or between the sheets to act as a protective interleaving material for preserving the pristine surface and for controlling moisture exposure of each glass sheet **621**; and paper sheets **623**, each of which is disposed between each two adjacent plastic films **622**. As can be seen from FIG. **6**, the upper edges of the paper sheets **623** project beyond the upper edge of the glass sheet **621**, and this facilitates removal of the paper sheets **623** after transportation and before the manufacturing process. The upper edge of the films **622** may or may not project beyond the upper edge of the glass sheet **621** depending upon preference.

[**0064**] One implementation of the preferred embodiment is preferably constructed with dimensions of width 1600 mm by height 1600 mm by depth 970 mm. The container **100** is enabled to accommodate up to 500 glass sheets **621** having dimensions extending to 1200 mm by 1300 mm with the long side of the sheet extending horizontally.

[**0065**] The present invention packaging system can be adapted easily to accommodate increases in glass size and container size.

[**0066**] From the foregoing description, in the container **100** of the present embodiment, the glass sheet stack **120** is disposed on the rigid metal pallet **110**, fixed in position by the pressing panel **440** and further sealingly covered with metal cover **130**, so that safe, high-density transportation of large glass sheets **621**, which hitherto had not been achievable, is enabled, resulting in significant reductions in transportation cost per glass sheet **621**.

[**0067**] In the preferred embodiment, the glass sheet stack **120** is transported in a sealed state, substantially reducing the risk of glass sheets **621** becoming contaminated during normal transportation. This, combined with the use of the non-adhesive protective films **622** attached on either side of the glass sheet **621**, contributes to significant reduction of the time required for the cleaning process prior to use of the glass sheet **621**.

[**0068**] Furthermore, the glass sheet stack **120** is held in the container **100** in an inclined position, so that the glass sheet stack **120** is kept stable and the introduction and extraction of the glass sheet stack **120** to and from the container is facilitated.

[**0069**] In accordance with a preferred aspect of the present invention and as mentioned supra, embodiments include entry slots **111***a*, for receiving a fork of a forklift truck, provided in the metal pallet **110**, so that the container **100** containing therein the glass sheet stack **120** which contains substrates **621**, paper sheets **623** and films **622**, can be easily transported within a warehouse or storage facility and easily loaded onto a delivery vehicle or the like.

[**0070**] In accordance with the preferred embodiment of the present invention, each of the cushioning members **116** is provided on the support panel **112** and the seat **113** and the pressing panel **116** (as shown in FIG. **4**), so that there is no risk of damaging the glass substrates **621**, and absorbing vibrations which may occur during transportation.

[**0071**] Further, the pressing panel **440**, disposed in contact with the front surface of the glass sheet stack **120**, is restrained relative to the support panel **112** of the pallet **110** by means of the two belts **450***a*, **450***b*, so that there is no possibility that the glass sheet stack **120** moves during transportation. In addition, the belt restraining devices **151**a and **151***b* are provided, so that the container can flexibly accommodate variations in the quantity and size of the glass sheets **621** (as well as variation in the thickness of the glass sheet stack **120**) and permit control over the retaining force applied to the surface of the glass.

[**0072**] Referring now to FIGS. **7-10**, in accordance with yet another preferred embodiment of the present invention, a container **700** is shown to include some additional features beyond those depicted in FIGS. **1** to **6**. These additional features pertain to an alternate glass restraint system primarily including a cover **710** with an integrated automated scissor restraint system **720**. It should be noted that the many of the structural elements found in FIGS. **1** to **6** can be carried over to FIGS. **7** to **10** such as for instance, the general frame design, the mechanical principles of the restraint system, and the fundamental materials of construction described supra. It should be noted that certain features such as the belts and pressing panel have been eliminated from this alternate embodiment.

[**0073**] Additionally, it should be noted that in FIGS. **7** to **10**, container cover **710**, is depicted as transparent to better illustrate the integrated internal restraint system though preferably, it is made of the same materials as discussed above in conjunction with containers described in FIGS. **1** to **6**. Transparent covers, however, may be desirable to one of skill in the art for providing visibility into the cavity of the container and are fully contemplated for use in the instant invention as it would assist those utilizing the container in viewing how many glass sheets are packaged into a container.

[**0074**] FIG. **7** shows cover **710** in a final resting position where the cover **710** is fully covering the glass support area with the glass sheets inside.

[**0075**] A retainer system **720** designed into cover **710** as shown in FIGS. **7** to **10**, such that an integral cover/glass retention type container **700**, is provided to facilitate automation, flexibility and stability. The integrated automated scissor restraint system **720** has one primary feature, namely integrated scissors, which will be discussed in more detail below. Cover **710** may include lifting attachments, not shown, to facilitate installation and removal of the cover.

[**0076**] Structural features of restraint system **720** that are designed into the cover **710** are shown in more detail in FIG. **8** which is a rear perspective view of the container **700**. Referring to FIG. **8**, the novel features in system **720** preferably include restraint scissors **810**, restraint bars **815**, clamping members **820** (similar to clamping member **136** described supra) to latch/unlatch the cover, locking mechanism (not shown) to hold the restraint bars in position following application of a specified amount of glass restraint force. When unlocked, the restraint bars **815** may be retracted from the glass allowing removal of the cover.

[**0077**] The restraint system **720** preferably incorporates a light-weight scissor-like mechanism **810**, which provides a wide range of motion, yet is simple in its approach. Scissor mechanism **810** is preferably made of aluminum tubing or extrusion. The restraint system **720** also incorporates restraint bars **815**, preferably made of aluminum tubing or extrusions, with the glass-facing surface including a cushion

similar to that of the pressing panel **440**. The restraint system **720** is also advantageous as it allows the container to accommodate a wide number of glass substrate requirements, ranging from 1 to N, where N represents the design count total for a given container.

[**0078**] For instance, in this preferred embodiment, when the cover **710** is installed on the main frame and touches the back of the support panel **730**, and after being affixed to the frame by the clamping members **820**, the integrated scissor-like mechanism **810** within the restraint system **720** operating from within the underside of the cover is activated and the "scissors"**810** begin to expand or open up. The scissors **810** will open up until the restraint bar **815** touches upon the top surface of the glass sheet resting on top of the stack of glass sheets, thereby holding in or restraining the glass sheets. This provides stability regardless how full the container is, since the glass sheets are not free to move around within the container. This embodiment accommodates the instance where there is only one sheet of glass as well as the instance where the container is filled to capacity, i.e. with N glass sheets, such that there is no room for more glass sheets to be added. In the former instance where there is one or just a few glass sheets, the scissors **810** would expand rather wide causing the restraint bar **815** to press up against the front surface of the forward-most glass sheet, as shown in FIG. **10**. And in the latter instance where there are many glass sheets in the container, the scissors would not expand as widely before the restraint bar **815** presses up against the front surface of the forward-most glass sheet, as shown in FIG. **9**. It should be noted that one or more scissor mechanisms **810** and one or more restraint bars **815** are contemplated by the present invention and would simply depend on design choice and effectiveness.

[**0079**] The mechanism utilized to operate the scissor-like mechanism can be applied automatically by a machine through an appropriate drive system, such as an electric motor or like device, or by a user via a simple mechanical crank or hand wheel for manual operation (not shown). Such a mechanism has the ability to set and maintain (i.e. lock) a predetermined amount of restraint force to a single sheet of glass or to the full capacity of the container or to any intermediate quantities of glass sheets.

[**0080**] Referring now to FIG. **11**, another alternate preferred embodiment of the present invention is shown having a container **1100** including a crank or hand wheel **1110** designed onto the cover **1120** for use in operating the restraining system. As shown, the crank **1110** would need manual operation. It is also contemplated by the present invention that the crank **1110** can be replaced with an interface for a tool or a robot to operate the system automatically. Also shown are counter-rotating right-angle gear boxes **1130** provided on the cover **1120** to translate rotary motion on vertical drive shafts **1140** to rotary motion on horizontal drive shafts **1141** and permit each side to rotate in opposite directions. Four torque-limiting devices **1150** on horizontal drive shafts **1141** ensure that appropriate restraint force is applied to the glass stack inside the container **1100**. Additionally, four locking devices **1160** on horizontal drive shafts **1141** secure the restraint after the appropriate force has been applied. Mechanical positioning devices such as dove-tail linear positioning stages **1170** are shown at four corners of the horizontal drive shafts **1141** with lead-screws (not shown) and are provided as a means of translating the rotary motion of the drive shaft **1141** into linear motion of the integrated retaining bars (shown infra in FIG. **13** parallel to the glass) into the front of the glass stack. The retaining bars are attached to the linear positioning stages **1170** at each end of the bar preferably in a horizontal orientation.

[**0081**] As shown in FIG. **12**, (shown in transparency for illustration purposes only), these stages **1170** include right-angle gear boxes **1180** for the interface to the horizontal drive shafts **1141**. Also shown in FIG. **12** is another right-angle gear box **1181** under the crank **1110** which translates the rotary motion from the crank **1110** to rotary motion on drive shafts **1140** and **1141**, respectively. Shaft support and coupling type devices are also included in the design.

[**0082**] Integrated retaining bar **1190** shown in FIG. **13** can move in and out from the inside front surface of the cover **1120** as required by the amount of glass sheets stacked in the container **1100**. The retaining bar **1190** preferably incorporates cushioning material as discussed supra in conjunction with other embodiments (not shown). Two retaining bars are shown in FIG. **13** near the top and bottom of the inside of the cover **1120**. Though two retaining bars **1190** are shown, the present invention contemplates the use of one or more retaining bars **1190** as needed for desired effectiveness. These top and bottom retaining bars **1190** preferably operate independently from each other in accordance with the preferred embodiment of the present invention. As such, adequate restraint on the glass stack where the glass thickness is not the same at the top as it is at the bottom, a condition commonly referred to as fanning, is provided. Additionally, torque limiting devices **1150** allow each end of the retaining bar **1190** to operate independently. This resolves instances where the retaining bar **1190** and glass surfaces are not parallel to each other, which can be caused by fabrication tolerances of the cover and frame, as well as potentially from the glass packing process itself.

[**0083**] In yet a still further alternate embodiment of the present invention, a restraint system similar to the more or less front-mounted system described in FIGS. **11-13**, can also be mounted on the back of the frame, such as retaining bar pulling system **1410** as shown in FIG. **14**. The system includes a gear box **1420**, torque limiting devices **1430**, lead screw devices or threaded shafts **1440** and drive shafts **1450** which rotate in the same direction. The pulling system **1410** is connected to the retaining bar (which remains integrated to the cover, not shown in FIG. **14**) via a detachable interface such as cable **1510** and hook **1520** as shown in FIG. **15** and further allowing for disconnection when there is a need for removal of the cover. Also shown in FIG. **15** is the attachment point for the retaining bar **1530**. The back-mounted embodiment incorporates many of the nuances of the front-mounted system as described supra.

[**0084**] The cover in the back-mounted embodiment preferably includes a retaining bar retraction mechanism **1600** shown in FIG. **16** to retract the retaining bar **1610** to the inside front surface of the cover thereby facilitating removal and installation of the cover preferably including springs **1620**, cables **1630**, or similar means capable of providing automated retraction. The attachment point **1640** of the retraction mechanism to the retaining bar is shown at the end of a cable **1630** and the attachment point of the back-mounted mechanical system to the retaining bar **1610** is shown at **1650** via cable **1510** and hook **1520**.

[0085] FIG. **17** provides an alternate inside view illustrating the above-mentioned attachment points **1640** and **1650** of both the retraction mechanism **1600** and the cable **1510** and hook **1520** apparatus to the retaining bar **1610** which is integrated into the cover as depicted.

[0086] Advantages to these preferred embodiments of the invention include enabling one of ordinary skill in the art to apply automated handling techniques where necessary and practical, (i.e. where size and weight limitations are recognized as potential problems for cover installation or removal and/or glass installation or removal), while also allowing for, in yet another alternate preferred embodiment system, manual operation which may still always be chosen if desired, in lieu of automatic operation.

[0087] A key advantage for the invention embodiments described herein is that the overall system design provides unrestricted access to the glass, which provides maximum flexibility for unloading the glass and removing the paper or other interleaving. Another key advantage is the ability to provide controllable and adjustable glass retention pressure to prevent the movement of glass during transportation.

[0088] The embodiments of the present invention described in FIGS. **1** to **17** allow for scalability up or down in size of glass sheets, accommodating different sizes of glass sheets within a defined range represented in a generation family, and maintaining the basic standards for glass orientation, such as inclined position, landscape orientation of the glass in the container, dust and weather resistant design construction, and the ability to pack as few as one (1) sheet of glass (without the use of dunnage or mechanical spacers to fill the gap between retainer and glass sheets) to as many as N glass sheets for high efficiency transportation and storage. The container described herein is reusable and as such, a cost-effective approach to packaging and transportation.

[0089] It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. Thus it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A container for packaging and transporting one or more glass sheets, comprising:

a frame having a pallet with a base;

a cover secured to said pallet such that said one or more glass sheets is sealably covered therewith;

a support panel and seat provided with cushioning members; and

restraining means for controllably and adjustably retaining said one or more glass sheets with respect to said support panel of said pallet.

2. The container according to claim 1, wherein the restraining means further comprises one or more retaining bars moving towards and away from the front of the one or more glass sheets and a mechanical system for moving said one or more retaining bars.

3. The container according to claim 2, wherein said restraining means is integrated into said cover.

4. The container according to claim 2 wherein said restraining means further includes a pressing panel coupled with said retaining bars.

5. The container according to claim 4 wherein said mechanical system further includes a plurality of belts and belt restraint devices.

6. The container according to claim 3, wherein said restraining means further includes at least one scissor-like mechanical system coupled to said one or more retaining bars.

7. The container according to claim 3, wherein said restraining means further includes a plurality of mechanical positioning devices coupled to said one or more retaining bars.

8. The container according to claim 2 wherein said mechanical system is integrated with said frame.

9. The container according to claim 8 wherein said mechanical system includes a retaining bar pulling system.

10. The container according to claim 2 wherein the restraining means is operated automatically.

11. The container according to claim 2 wherein the restraining means is operated manually.

12. The container of claim 1 wherein said cover is sealably affixed to the frame via a gasket seal.

13. The container of claim 4 wherein said pressing panel is removable.

14. The container of claim 2 wherein said retaining bars operate independently from each other.

15. The container of claim 11 wherein said restraining means further comprises vertical posts.

16. The container according to claim 1 wherein the frame and cover are made of a metal or other composite material.

17. The container according to claim 1 can accommodate a range of sizes for said one or more glass sheet sizes.

18. The container according to claim 1, wherein said one or more glass sheets are stacked with no spacing in between.

19. The container according to claim 18 wherein non-scratching interleaf materials are positioned between the glass sheets.

20. The container according to claim 19 wherein said interleaf materials further comprise non-adhesive plastic films attached on either side of each glass sheet.

21. The container according to claim 19 wherein a paper sheet is disposed between each of said interleaf materials.

* * * * *