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(54) **Title**: THERMAL CONTAINMENT SYSTEM PROVIDING TEMPERATURE MAINTAINING SHIPPING PACKAGE WITH SEGMENTED FLEXIBLE PCM PANELS

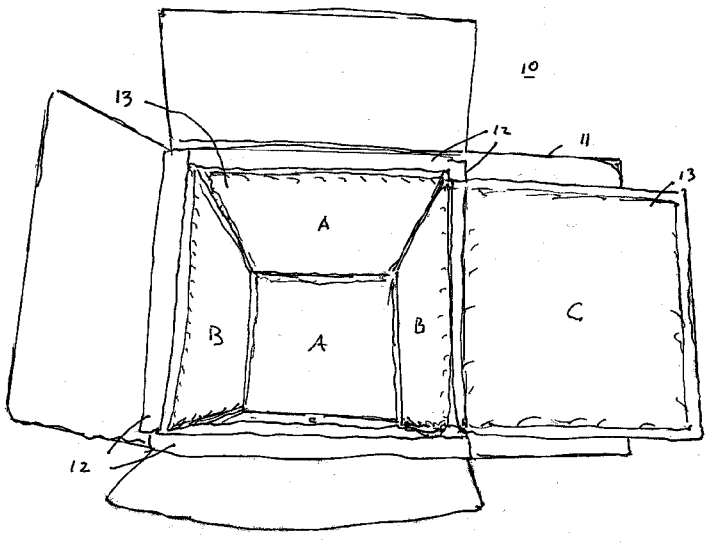

FIG. 4

(57) **Abstract**: A packaging system having an outer container and a segment panel defining a plurality of phase change material (PCM) segments, with said segments being aligned with sides of the outer container interior upon wrapping around a payload and insertion into the outer container. The segmented panels may include edge tapers which facilitate the wrapping process with adjacent edge tapers being brought together during the wrapping process. A method of packaging using PCM-containing segments which are wrapped around a portion of a payload is also disclosed.

WO 2010/132726 A1

THERMAL CONTAINMENT SYSTEM PROVIDING TEMPERATURE MAINTAINING SHIPPING PACKAGE WITH SEGMENTED FLEXIBLE PCM PANELS

RELATED APPLICATIONS

[00001] This application claims priority to pending U.S. Ser. No. 61/177,998, filed May 13, 2009, and hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[00002] The present invention is directed to a thermal containment system providing a package for a temperature sensitive product and a method of use. More particularly, the present invention relates to a package and method of use for shipping temperature sensitive materials via common carriers, such as United States Postal Service, United Parcel Service, FedEx, etc.

BACKGROUND OF THE INVENTION

[00003] The conventional means of shipping temperature sensitive materials such as blood and medical products involves the use of an insulated box along with some cooling agent. These cooling agents are typically a frozen gel, dry ice, or glistening (wet) ice.

[00004] There are, however, several problems with the conventional approach. First, the insulation material often does not degrade readily, leading to disposal problems. These problems are so severe that many countries ban the use of styrofoam, thus severely restricting international shipments of biological materials. Second, the cooling agents also present numerous practical problems in field use. Specifically, gel systems are often too expensive for routine use and disposal. As for dry ice, the carbon dioxide gas evolved during shipment may be dangerous to shipping personnel. Wet ice poses handling problems in packing, as well as leakage and product soaking problems.

[00005] Many previously existing shipping systems also suffer the disadvantage that they are not capable of maintaining the shipped product or payload within a target temperature range. Various biological products, such as platelets, whole blood, semen, organs and tissue, must be maintained above a predetermined minimum temperature and below a predetermined maximum temperature. Pharmaceutical products are also commonly required to be kept within a specified

temperature range. Food products, flowers and produce frequently have preferred storage temperature ranges as well. Many known methods and systems for shipping such products are not able to keep temperatures within the desired range. The result of this practice is excessive cooling, frequently resulting in damage to the product.

[00006] Previously known methods and systems which are capable of maintaining a payload within a specified temperature range have been found to be unsuited to certain applications, unduly complex in practice, and/or prohibitively expensive. For example, refrigerated containers require associated compressors, coils, crystals, or other equipment, which adds to the apparatus' expense, weight and size. Additionally, this type of equipment generally requires batteries or connection to an external power source. Refrigerated containers also require ventilation, so that heat from the payload can be rejected to the ambient. Sufficient ventilation for the proper operation of these devices is generally unavailable in the closely-packed cargo compartments of common carrier transport vehicles. Refrigerated transport vehicles exist, but are substantially more expensive than unrefrigerated transport, and are not as readily available.

[00007] Another problem often observed with conventional systems is failure to maintain the proper temperature over time, due to inadequate insulation and/or inadequate cooling pack capacity. Again, the end result is product damage.

[00008] The consequence of these observed shortcomings of conventional shipping systems is damage to the material being transported. For biomedical materials such as blood, blood products, pharmaceuticals, etc., loss of these products due to heat damage is critical because of the intrinsic financial value of these items and because of the potential health hazards that the use of compromised materials presents. Likewise, heat damage to various foods also presents both financial and health consequences.

[00009] Packages incorporating phase change materials for transport of temperature sensitive payloads are well known. A phase change material (PCM) is a substance with a high heat of fusion which, upon melting and solidifying at certain temperatures, is capable of storing or releasing large amounts of energy. Initially, solid-liquid PCMs perform somewhat like conventional storage materials: their temperature rises as they absorb heat. Unlike conventional storage materials, however, when such PCMs reach their phase change temperatures (i.e., melting point temperature)

they absorb large amounts of heat without a significant rise in temperature. When the ambient temperature around a liquid material falls, the PCM solidifies, releasing its stored latent heat. Certain PCMs store 5 to 14 times more heat per unit volume than conventional storage materials such as iron, masonry, or rock.

[00010] Transporting temperature sensitive materials through environments having extreme ambient temperatures in a manner that does not require a power source or other mechanical device is desirable. Various methods have been advanced for this purpose. For example, prior known devices have employed phase change materials in liquid form to encase a payload to protect materials from colder ambient temperatures and phase change materials in solid form to encase a payload to protect materials from hotter ambient temperatures. PCMs can be broadly grouped into two categories: "Organic Compounds" (such as polyethylene glycol) and "Salt-based Products" (such as Glauber's salt). The most commonly used PCMs are salt hydrides, fatty acids and esters, and various paraffins (such as octadecane). Ionic liquids have also been investigated as novel PCMs.

BRIEF SUMMARY OF THE INVENTION

[00011] The present invention relates to a package and method of encasing a payload with phase change materials and an outer container, wherein the PCM material is provided in segmented panels. In one embodiment, a payload is surrounded with phase change material contained within segmented PCM panels that are wrapped around a payload. A package in accordance with the present invention may include multiple segmented panels of phase change material with each segment including a generally rigid insert for lightweight, structural stability.

[00012] An embodiment of the present invention includes a package defined by an outer container, such as a container, which contains insulated panels and one or more flexible, segmented PCM panels surrounding a payload. In one example, the segments are defined by bondings between panel surfaces. Such a bond can be formed via a film thermal bonding procedure. One embodiment of the present invention utilizes multiple panels of generally similar form to define a plurality of segmented PCM portions.

[00013] It is desired to have a lightweight, highly reliable, portable container that maintains the temperature of pharmaceutical products or other temperature sensitive materials over a relatively long or given period of time. For pharmaceutical products/materials for example, it is desired to maintain thermal stability to allow the material to ultimately be administered to patients many hours or days after they were first placed into the container.

[00014] An embodiment of the present invention includes a thermal management system. The thermal management system includes a plurality of PCM-containing panels connected together to form a segmented PCM module. The system further includes a phase change material occupying voids of corrugated panels within an interior of the plurality of panels, and a liquid container, such as film, to at least prevent the phase change material from leaking out of the interior of the plurality of PCM-containing panels.

[00015] Another embodiment of the present invention includes a method of manufacturing a thermal management system. The method utilizes a horizontal fill-and-seal machine. The method comprises securing a bottom film layer into a cavity form, such as via a vacuum, and dispensing PCM fluid into the formed cavity. Corrugated paper insert elements are then placed into the cavity and physically held in place to allow air to escape the flutes of the corrugated paper elements while the PCM fluid saturates the corrugated paper elements. A top film layer is then placed above the cavity and the top and bottom film layers are heat sealed together to provide a fluid-tight cavity. The method further provides forming a plurality of PCM-containing cavities simultaneously wherein a step includes sealing the phase change material and plurality of corrugated insert panels within a plurality of cavities to define a segmented PCM panel.

[00016] A further embodiment of the present invention includes a method of using insert panels within each PCM-containing cavity and wherein the insert panels are cut in complimentary manner that facilitates the fit between the PCM-containing panels and cavities. In one such embodiment, the multiple insert panels may be pre-cut with an edge taper to define a plurality of tapered edges. These tapered edges permit closer engagement between adjacent PCM panels once formed into a desired shipping configuration.

[00017] A further embodiment of the present invention includes a method of using multiple insert panels within each PCM-containing cavity and wherein the multiple insert panels are

of different size relative to each other. In one such embodiment, the multiple insert panels may be decreasing in size to define a plurality of tapered edges. These tapered edges permit closer engagement between adjacent PCM panels once formed into a desired shipping configuration.

[00018] A further embodiment of the present invention includes a method of using a pair of segmented PCM panels, with each panel being defined by three PCM-containing segments. The PCM panels are formed into a generally C-shaped form once inserted into an outer container. The pair of PCM panels can thus cover all six sides of a rectangular form.

[00019] A further embodiment of the present invention includes a method of using a single segmented PCM panel. The PCM panel is formed into a generally rectangular form prior to insertion into an outer container. Segments of the PCM panel cover all six sides of a rectangular form. Some or all of the segments of the PCM panel may include an insert panel to provide lightweight, structural stability.

[00020] A further embodiment of the present invention comprises a method of using a thermal management system. The method comprises thermally preconditioning a container at a preconditioning temperature for a predefined period of time. The container is designed to include a plurality of segmented PCM panels, a phase change material occupying voids within the interiors of the plurality of panel segments and voids within an insert panel(s), and a liquid barrier to at least prevent the phase change material from leaking out of the interior of the plurality of panel segments. The method further includes opening the container, placing at least one pharmaceutical product or material into the container, and closing the container. The method also comprises shipping the container to a destination location during a predetermined time period such that a temperature of the at least one product stays within a predetermined temperature range over the predetermined time period due to the design of the container.

[00021] Another embodiment of the present invention comprises a thermal management system. The thermal management system comprises a plurality of insert panels formed as structurally porous panels and connected together to form a container. A phase change material occupies voids or gaps within an interior of the plurality of structurally porous panels. The system further includes a liquid or fluid barrier material, such as a film layer, to at least prevent the phase change material from leaking out of the interior of the plurality of structurally porous panels.

[00022] In one preferred form, the present invention provides a system and method for maintaining a payload within a temperature range, between a minimum temperature and a maximum temperature. The invention includes a first temperature control material having a first phase change temperature sufficiently above the minimum temperature in the range to ensure the payload does not fall below the minimum temperature in the range, and a second temperature control material having a second phase change temperature sufficiently below the maximum temperature in the range to ensure the payload does not rise above the maximum temperature in the range. In one embodiment, the first material exists as a liquid within the target temperature range, and the second material as a solid. The first material changes from its liquid phase to its solid phase at a temperature sufficiently above the minimum temperature in the range to ensure the payload does not fall below the minimum temperature in the range, and the second material that changes from its solid phase to its liquid phase at a temperature sufficiently below the maximum temperature in the range to ensure the payload does not rise above the maximum temperature in the range. In this manner, the latent heats associated with the respective phase changes assist in maintaining the temperature of the payload within the range. Virtually any desired target temperature range may be accommodated by appropriate selection of the first and second materials.

[00023] The present invention further includes heat transfer devices which can take any of a number of forms, including without limitation: flexible plastic pouches, rigid or semi-rigid panels, and/or blister packs. The heat transfer devices comprise one or more reservoirs for containing the first and second materials. Separate heat transfer devices can be provided for each of the first and second materials or, alternatively, a single heat transfer device can be segmented into separate reservoirs for each of the first and second materials. Baffles or other separation means can be provided within the heat transfer devices for maintaining the first and second materials in position.

[00024] The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of

the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[00025] For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

[00026] FIGURE 1 is an view of a package of a thermal containment system in accordance with the present invention.

[00027] FIGURES 2 through 6 are perspective views of the package of FIGURE 1 depicting progressively disassembled states.

[00028] FIGURE 7 is a view of a segmented PCM-containing panel of FIGURE 1.

[00029] FIGURE 8 is a detailed view of the segmented PCM-containing panel of FIGURE 7.

[00030] FIGURE 9 is a detailed cross-sectional view of a segmented PCM-containing panel of FIGURE 7.

[00031] FIGURE 10 is a detailed view of a segmented PCM-containing panel of FIGURE 7 as formed to define a corner, such as around a payload section.

[00032] FIGURE 11 is a perspective view of a segmented PCM-containing panel provided in flat form.

[00033] FIGURE 12 is a perspective view of the PCM panel of FIGURE 11 as manipulated into a generally rectangular form.

DETAILED DESCRIPTION OF THE INVENTION

[00034] The packaging system of the present invention was developed for shipments of goods which must be kept within narrow temperature ranges over a period of days under uncontrolled ambient temperature conditions. Such goods include biological products, blood products, vaccines, pharmaceuticals, chocolate products, latex paints, etc. The system described herein can be configured to maintain controlled product temperatures under both high and low ambient temperature conditions.

[00035] This system uses phase change materials for tight temperature control and minimum shipping weight and volume. These phase change materials are reusable, and can save significantly on shipping costs. Various numbers of layers of phase change material may be used based upon time requirements, ambient temperature requirements, thermal insulation factor of the outer container, and the degree of temperature control required for the product. Descriptions of various phase change materials, parameters and engineering constraints are provided in US Pat. Nos. 5,899,088; 6,482,332; and 7,328,583, the disclosure of each being incorporated herein by reference.

[00036] With reference to FIGURE 1, there is shown one embodiment of a thermal management system including a package 10 in an assembled state. Package 10 includes an outer container 11 having a top wall, bottom wall and side walls. Package 10 includes outer container 11 containing an arranged plurality of insulation panels and segmented PCM panels. In the illustrated embodiment, container 11 is a rectangular box. Container 11 may be insulated or uninsulated. In other embodiments, container 11 may assume alternative forms, including, but not limited to, nonrectangular forms. Container 11 may be of plastic or polymer material, corrugated paper or corrugated plastic or other suitable material.

[00037] FIGURES 2 through 6 illustrate perspective views of package 10 and depict disassembly of the package 10 of FIGURE 1 to reveal a payload section. In FIGURE 2, the top walls of container 11 are opened to reveal a plurality of insulation panels 12. Separate insulation

panels 12 are provided adjacent each of the six sides of container 11. FIGURE 3 depicts the package 10 with the top insulation panel 12 removed. A PCM panel 13 is thereby exposed.

[00038] FIGURE 4 depicts the package 10 with the top segment of the PCM panel 13 opened to reveal a payload section. A second segmented PCM panel 13 is also shown to wrap around 3 sides of the payload section. FIGURE 5 depicts the package 10 of FIGURE 4 with the second segmented PCM panel 13 removed. FIGURE 5 illustrates the first segmented PCM panel 13 wrapping around the payload section along top, side and bottom portions thereof. FIGURE 6 shows the package of FIGURE 5 with both PCM panels 13 removed. One of the insulation panels 12 is also depicted as removed from the interior of package 10. Insulation panels 12 can include vacuum insulation panels. While insulation panels 12 in the embodiment of FIGURE 1 are generally rectangular in form, panels 12 can assume a variety of other shapes and forms in alternative embodiments of the invention. Six generally identical insulation panels 12 are employed in the embodiment of package 10 of FIGURE 1.

[00039] As described hereinafter, the PCM panels 13 include a plurality of inserts, such as corrugated material, for lightweight, structural stability. The inserts are preferably contained within each PCM segment and provided in direct contact with the phase change material.

[00040] FIGURE 7 illustrates a pair of segmented PCM panels 13. PCM panels 13 may assume different shapes or forms in alternative embodiments of the invention. Panels 13 each contain a plurality of PCM segments 18. In the illustrated embodiments of FIGURES 1 - 7, a pair of flexible, segmented PCM panels 13 are employed in package 10 and are defined by three PCM-containing segments 18. These segments 18 are separated by linear voids 19. Voids 19 may be defined during a thermal bonding manufacturing process. For example, the voids 19 and cavity forming segments 18 may be formed from a pair of thermoplastic sheet materials brought together during a thermal bonding / filling process. Voids 19 may be continuous, that is to say each segment 18 is separated from each other and PCM is prevented from flowing from one segment 18 to an adjacent segment 18. In another embodiment, voids 19 may be non-continuous and PCM is able to flow from one segment into another segment 18 when an external force is supplied. In short, the interior volumes of segments 13 may be either separated or provided in fluid communication with each other.

[00041] FIGURE 7 illustrates an insert 20 contained within PCM segments 18. FIGURE 8 illustrates a side perspective view of a pair of PCM-containing segments 18 of a PCM panel 13. FIGURE 9 depicts a cross-sectional view taken through one of the segments 18 of the PCM panel 13. As shown, a plurality of inserts 20 are contained within each segment 18. Inserts 20 are described in US Pat. No. 7,328,583, entitled *Thermally Stable Containment Device and Methods*, assigned to Entropy Solutions, Inc., and incorporated by reference herein for all purposes.

[00042] Inserts 20 may be corrugated, porous or fibrous panels which provide lightweight, structural stability to the panel segments 18. In one embodiment, inserts 20 are formed of a corrugated paper material adapted to be saturated by liquid PCM within the segment 18. As shown in FIGURE 8, the edges of the panel segments 18 are generally tapered. This tapering effect results from stacking progressively smaller inserts 20 as shown in FIGURE 9. FIGURE 10 illustrates one benefit of the tapered edges whereby an adjacent pair of panel segments forms a relatively tight corner containing PCM from both panel segments 18.

[00043] In accordance with an embodiment of the present invention, the PCM comprises a material which melts and solidifies within a certain temperature range profile and, in doing so, is capable of storing or releasing energy. As a result, the PCM can be used to help maintain or regulate the temperature of materials within the container (e.g., pharmaceutical products or blood). For example, a PCM may be designed to change phase (i.e., melt or solidify) in a temperature range conducive for storing bags of human blood. If for a particular application, thermal protection at a given temperature is required and there is no PCM that changes phase at that temperature, it is possible to mix two or more PCMs and arrive at the desired phase change temperature of the mixture.

[00044] As shown in FIGURES 9 and 10, each segment 18 contains a quantity of PCM held between upper and lower films 24, 26. In one embodiment, segments 18 are defined between film layers 24, 26 brought together during a sealing/filling process. PCM is held within segments 18 defined by film layers 24, 26. The size of segments 18 could depend on a variety considerations including, but not limited to, temperature constraints of payload and/or anticipated ambient temperature during shipping, size of payload, size or weight limitations of shipper, etc. It

should be appreciated that alternative segment 18 designs could also be utilized depending, for example, on the geometry of the payload, thermal constraints, etc.

[00045] FIGURE 10 is an exemplary illustration of an embodiment of a layered structure of corrugated panel inserts 20 used to form a side of the passive thermal management system of FIGURE 1, in accordance with various aspects of the present invention. The layered structure comprises multiple corrugated layers. Each corrugated layer includes flutes, gaps and voids, which are filled with PCM. FIGURE 10 illustrates that a pair of tapered edge structures of adjacent pairs of segments 18 are brought together during a wrapping process, with said pair of edge structures cooperating to define a corner. By so tapering the edges of the segments 18, a relatively air-tight and energy-efficient corner structure is provided upon wrapping the segments 18 about a payload. While the edge structures are illustrated as generally 45 degree tapers, alternative box shapes may utilize edge structures which are angled differently as compared to that of FIGURE 10.

[00046] FIGURES 11 and 12 illustrate another embodiment of the present invention wherein a segmented flexible PCM-containing panel 13 is used. Panel 13 is defined by a pair of outer layers, such as plastic film, which are segmented to contain PCM. Panel 13 includes a plurality of PCM-containing segments 18 designated A, B, C and D. Some of the segments 18 may include panel inserts 20. For example, central segments 18 A, B, C and D may contain a panel insert 20 and the end segments 18 A_i, B_i, C_i, D_i and/or 18 A_{ii}, B_{ii}, C_{ii}, D_{ii} would not contain an insert 20. In the illustrated embodiment, panel 13 includes a plurality of cuts between A_i and B_i, B_i and C_i, C_i and D_i, A_{ii} and B_{ii}, B_{ii} and C_{ii} and C_{ii} and D_{ii} to facilitate the folding of the panel into a three dimensional temperature protection package.

[00047] Another aspect of the embodiment of FIGURES 11 and 12 is the provision that the segmented PCM panel 13 can be manipulated from a flat form, as shown in FIGURE 11, into a box form 120 as shown in FIGURE 12. In this manner, all six sides of the box 120 are provided with a PCM segment 18. Ends 122 of the box 120 include overlapping PCM segments 18. The ends 122 may be secured together to define a closed box using an adhesive, hook and loop fastener, or other mechanical or chemical fastening means. The adhesive or fastener may be provided upon the PCM panel 13 during manufacturing or placed during assembly into the box form 120.

[00048] A method of using the embodiment of FIGURES 11 and 12 would include providing a PCM panel 13 in flat form, preconditioning the PCM panel 13 at a desired temperature, folding the PCM panel 13 into a box form 120, placing a payload within the PCM box 120, and inserting the PCM box 120 into an outer container 124. During the folding step, adhesives or other fasteners may be used to seal sides of the PCM box. Also during the folding step, inserts 20 within one or more of the panel segments 18 promote folding of the panel 13 along pre-configured linear voids 19.

[00049] In accordance with various embodiments of the present invention, more than two corrugated layers may be used to form a layered structure of corrugated panels for use in a thermal management system. In general, the design of each layer (thickness, PCM, trigger agent, barrier material, etc.) and the number of such layers determines the thermal performance of the panel and, therefore, of the overall resultant container (i.e., thermal management system). Numerical simulations and/or algorithms may be used to determine the design of the thermal management system for a desired thermal performance (i.e., maintaining a desired temperature range over a desired period of time). The algorithms may also take into account cost, allowing a designer to balance cost versus number of PCM layers and insulation layers, for example.

[00050] The present invention is also directed to a package and method for encasing a payload cavity with flexible, segmented panels 13 containing phase change material. In one example, a water based phase change material is combined with another phase change material to provide thermal protection for the payload. In another embodiment, the phase change material may include thermodynamically effective quantities of octyl laurate. By properly selecting the phase change materials, a package can be configured to provide maximum thermal protection for a temperature sensitive product during delivery. Employing a combination of solid and liquid phase change materials in the container can provide protection from both hotter and colder ambient temperatures during delivery, and a beneficial reduction in the amount of certain phase change materials can result.

[00051] Embodiments of the present invention may include two or more different phase change materials. In one embodiment, a water-based phase change material is utilized along with a second, non-water-based phase change material. In one embodiment, a temperature sensitive

product is protected against thermal damage from the water-based phase change material by an intermediate phase change material. Depending on the desired temperature range, a variety of different phase change materials may be utilized to keep a temperature sensitive product warm or cold during shipment through an environment having substantially different temperatures than desired. For example, prior to shipment one or both of the phase change materials can be preconditioned so that phase change material is in liquid form or solid form. Depending on the anticipated ambient temperature profile, the most effective combination of solid and liquid phase change material can be selected. If additional protection is needed, auxiliary phase change material in solid, liquid, or solid and liquid phase can be added to augment the thermal capabilities of the container.

[00052] Selection of the phase change materials may include consideration of multiple factors including, but not limited to, the desired protected temperature range, anticipated ambient temperatures during shipment, thermal properties of the different phase change materials, thermal properties of the container and/or insulation panels, and thermal properties of the temperature sensitive product being shipped. The design and sizing of containers for the phase change material and the insulation panels could vary depending on these factors as well.

[00053] A temperature maintaining packaging system in accordance with the present invention includes an insulated or non-insulated outer container, including but not limited to a box or envelope made of plastic film, metallic foil or other suitable material, a phase change material panel or panels consisting of a sealed cavity or cavities within a plastic film or other suitable material that is/are preconditioned to be solid, liquid, or solid and liquid in varying predetermined combinations covering or mostly covering the interior of the outer container or envelope, and possibly a secondary phase change material sealed within a plastic film or other suitable material having a single cavity or multiple cavities that is/are preconditioned to be solid, liquid, or solid and liquid in varying predetermined combinations covering or mostly covering the interior of the first phase change material panel or panels all to thermally protect a payload within the center of the package.

[00054] A temperature maintaining packaging system in accordance with the present invention includes an outer rigid or semi-rigid tube or hollow container made of paper, plastic or

other suitable material along with suitable caps for enclosing the package, a suitable insulation such as a plastic foam capable of wrapping around a phase change material panel or panels and a payload container, a phase change material panel or panels consisting of a sealed cavity or cavities within a plastic film or other suitable material that is/are preconditioned to be solid, liquid, or solid and liquid in varying predetermined combinations covering or mostly covering the interior of the outer container, and possibly a secondary phase change material sealed within a plastic film or other suitable material having a single cavity or multiple cavities that is/are preconditioned to be solid, liquid, or solid and liquid in varying predetermined combinations covering or mostly covering the interior of the first phase change material panel or panels all to thermally protect a payload within the center of the package.

[00055] The temperature maintaining package system in accordance with the present invention includes PCM panels wherein the phase change materials are preconditioned to be solid, liquid, or both solid and liquid.

[00056] The invention is also directed to a method of preparing, packaging and shipping a container or envelope to thermally protect a payload of temperature sensitive materials including: wrapping the payload material to be thermally protected in a phase change material panel with one or more segments of phase change material conditioned to be solid or liquid; wrapping the payload and initial phase change material panel in a secondary phase change material panel with one or more segments of phase change material conditioned to be solid or liquid; as needed, wrapping the payload and panels with successive layers of phase change material panels as space and temperature protection demands; placing the payload wrapped with phase change material panels into the outer container or envelope; and sealing the payload and phase change material panels inside the container and performing any necessary operations to complete the package such as but not limited to placing shipping information on the package, placing postage and instructions on the package, or puncturing a vacuum sealed outer envelope to allow expansion of the insulation material.

[00057] Another method of preparing, packaging and shipping a container to thermally protect a payload of temperature sensitive materials includes: wrapping the payload material to be thermally protected in a phase change material panel with one or more cavities of

phase change material conditioned to be solid or liquid; wrapping the payload and initial phase change material panel in a secondary phase change material panel with one or more cavities of phase change material conditioned to be solid or liquid; as needed, wrapping the package in successive layers of phase change material panels as space and temperature protection demands; wrapping the payload wrapped with phase change material panels with suitable insulation such as foam insulation; placing the payload wrapped with phase change material panels and insulation into the outer container or envelope; and sealing the payload, phase change material panels, and insulation inside the container and performing any necessary operations to complete the package such as but not limited to attaching end caps to the container, placing shipping information on the package, or placing postage and instructions on the package.

[00058] The PCM panels may include phase change materials that have been preconditioned separately to be solid and liquid by adding heat energy to phase change material containers until the phase change material is completely liquid and conditioning the liquid phase change material to be at an acceptable temperature for packaging; or removing heat energy from phase change material containers until the phase change material is completely solid and conditioning the solid phase change material to be at an acceptable temperature for packaging.

[00059] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

CLAIMS

1. A transport package for a temperature sensitive payload comprising:

an outer container having an interior defined by at least three sides;

a panel defined by a plurality of interconnected segments containing phase change material and at least one insert; and

a payload section adapted to receive the temperature sensitive payload, with the panel being wrapped around the payload prior to insertion into the outer container, and with at least three of said plurality of interconnected segments being aligned with said at least three sides of the outer container.

2. The package of claim 1 wherein the panel includes a pair of intermittently joined film layers defining cavities into which said phase change material is received.

3. The package of claim 2 wherein the panel includes a plurality of voids defined by a plurality of inserts.

4. The package of claim 3 wherein some of the voids are defined by flutes of a corrugated paper product.

5. The package of claim 3 wherein edges of the plurality of inserts taper, and when the panel is folded into form, said edges of adjacent pairs of inserts are brought together.

6. The package of claim 5 wherein the at least one insert includes a plurality of sheets of corrugated product.

7. The package of claim 6 wherein said plurality of sheets includes multiple sheets of decreasing size.

8. A method of packaging a temperature sensitive product comprising:

thermally preconditioning a flexible phase change material-containing panel, said panel including a plurality of segments containing at least one insert;

wrapping the panel around at least a portion of the temperature sensitive product; and

inserting the temperature sensitive product wrapped with the panel into an outer container, with said plurality of segments being aligned with a plurality of inside surfaces of said outer container.

9. The method of claim 8 further comprising:

thermally preconditioning a second flexible phase change material-containing panel and wrapping the second flexible phase change material-containing panel around the temperature sensitive product prior to said inserting.

10. The method of claim 8 wherein said at least one insert is a corrugated product.

11. The method of claim 8 wherein said at least one insert has tapered edges and wherein said wrapping brings together a pair of tapered edges of an adjacent pair of inserts to define a corner.

12. The method of claim 8 wherein said panel includes 6 segments and wherein said wrapping aligns the 6 segments with 6 interior sides of the outer container.

13. The method of claim 8 wherein said panel includes 12 segments and wherein said wrapping aligns the 12 segments with 6 interior sides of the outer container.

14. A method of packaging a temperature sensitive payload comprising:

wrapping the payload in a first flexible, segmented panel containing an insert and phase change material preconditioned based on an anticipated ambient temperature during transport of the payload;

wrapping the payload in a second flexible, segmented panel containing an insert and phase change material preconditioned based on another anticipated ambient temperature during said transport; and

inserting the payload wrapped with the segmented panels into an outer container, with panels of said segmented panels being aligned with inside surfaces of said container.

15. The method of claim 14 further comprising:

wrapping the payload with thermal insulation prior to said inserting.

16. The method of claim 14 wherein at least some phase change material has been preconditioned by adding heat energy to the at least some phase change material until the at least some phase change material is liquid.

17. The method of claim 14 wherein at least some phase change material has been preconditioned by removing heat energy from the at least some phase change material until the at least some phase change material is solid.

18. The method of claim 14 wherein the segmented panels are thermally preconditioned based on anticipated ambient temperatures during payload transportation.

19. The method of claim 14 wherein at least two different thermal preconditioning processes are used to prepare the segmented panels.

20. The method of claim 14 wherein said wrapping the payload in the first flexible, segmented panel includes providing the first panel in flat form and folding the first panel into a box form prior to inserting the payload.

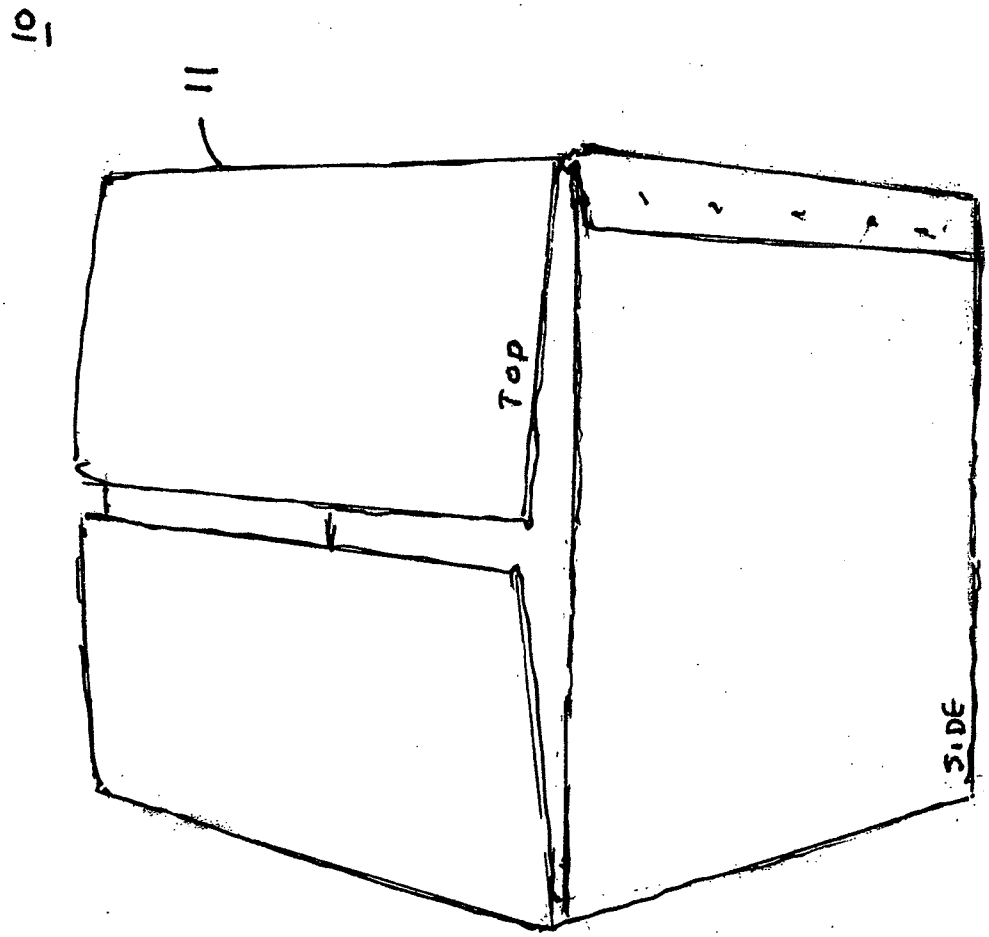

FIG. 1

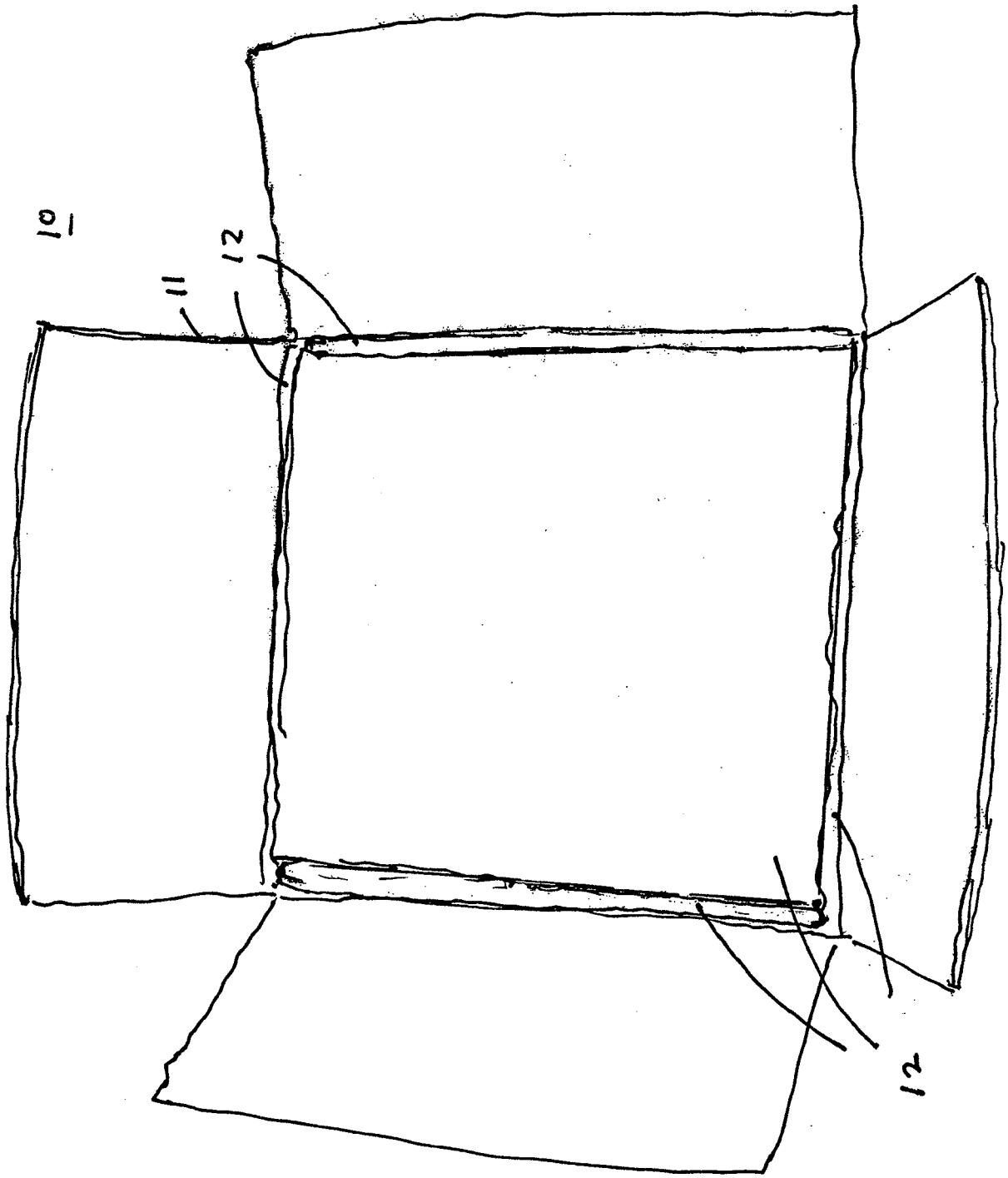

FIG. 2

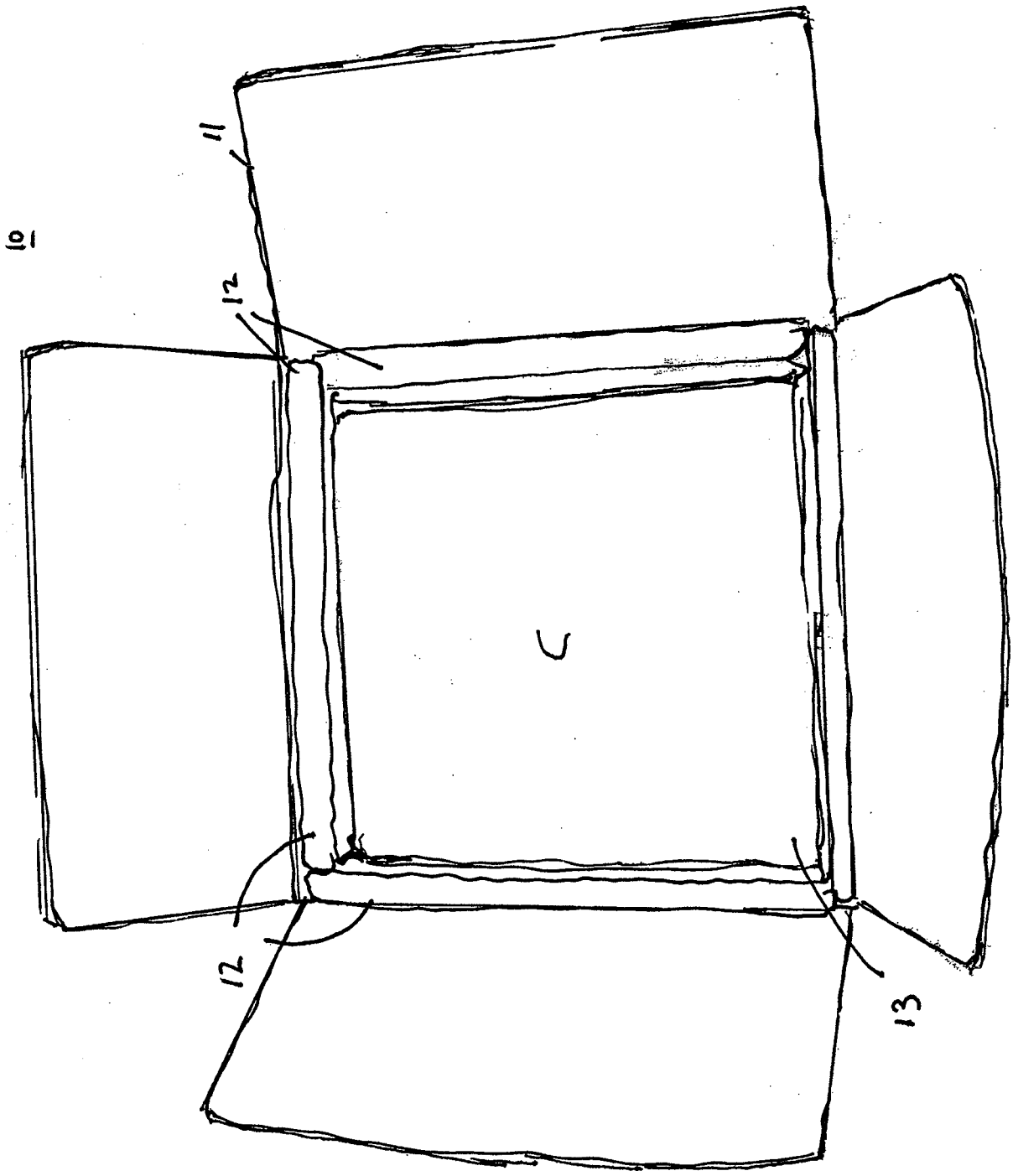

FIG. 3

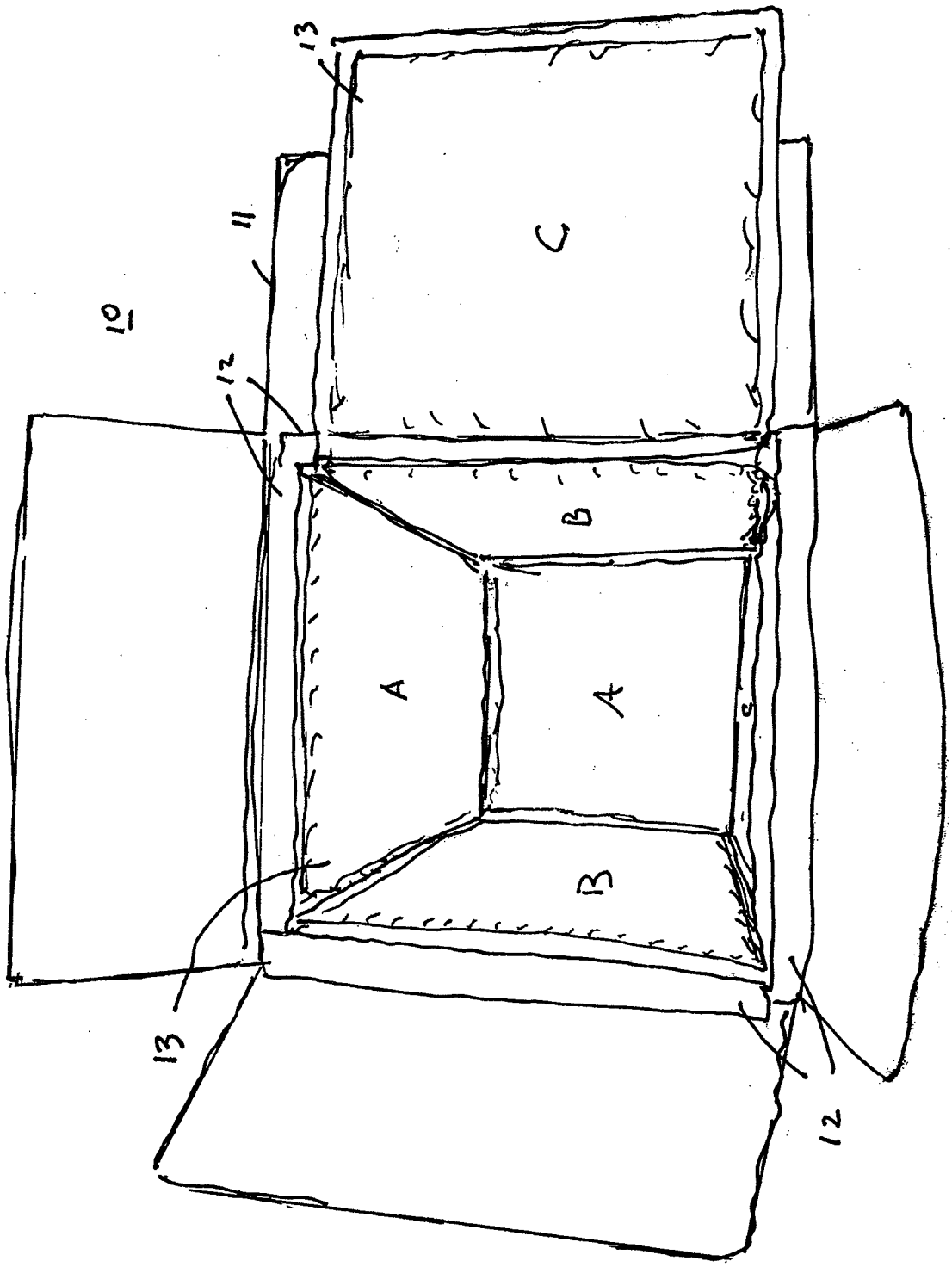

FIG. 4

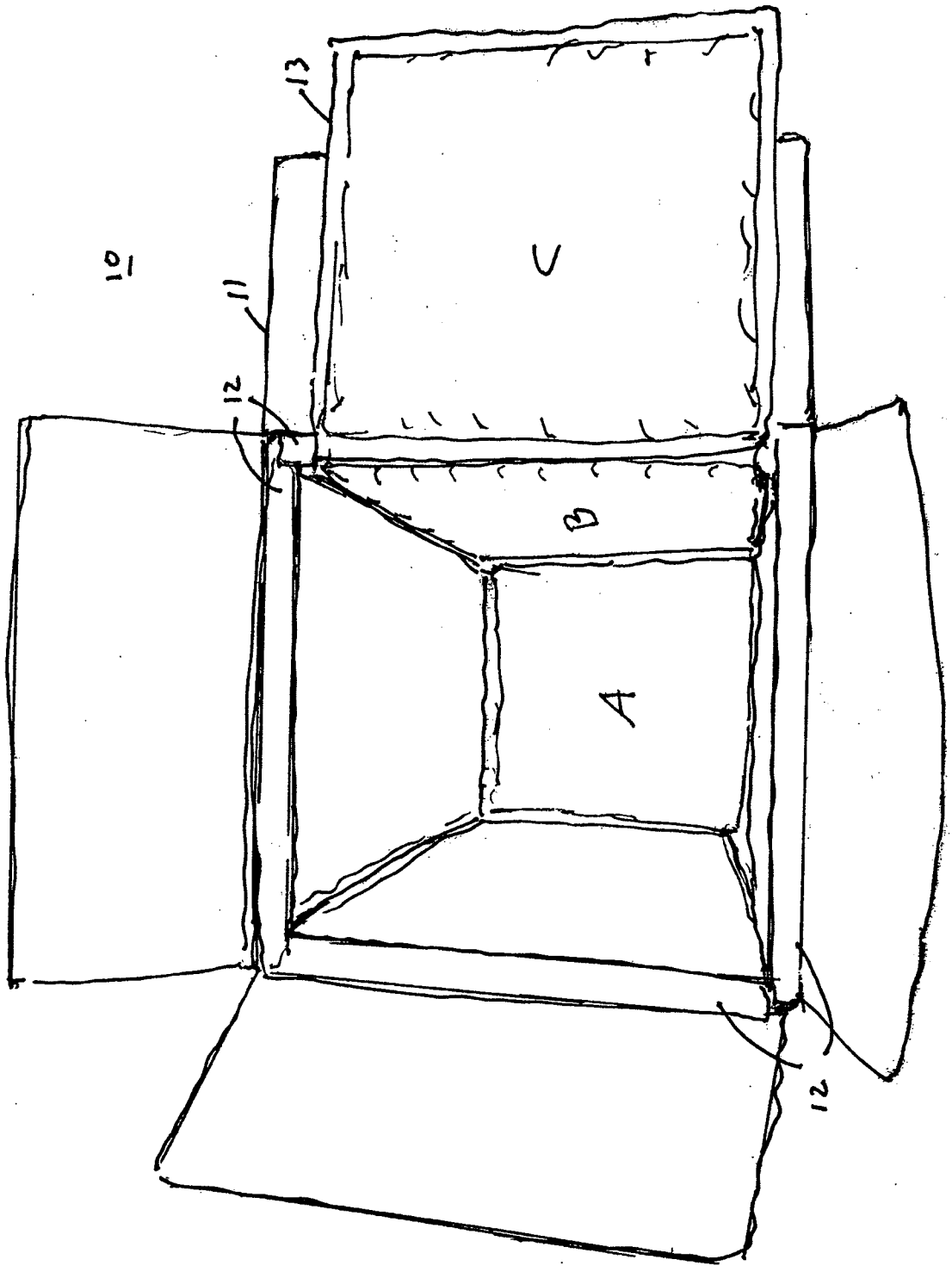

FIG. 5

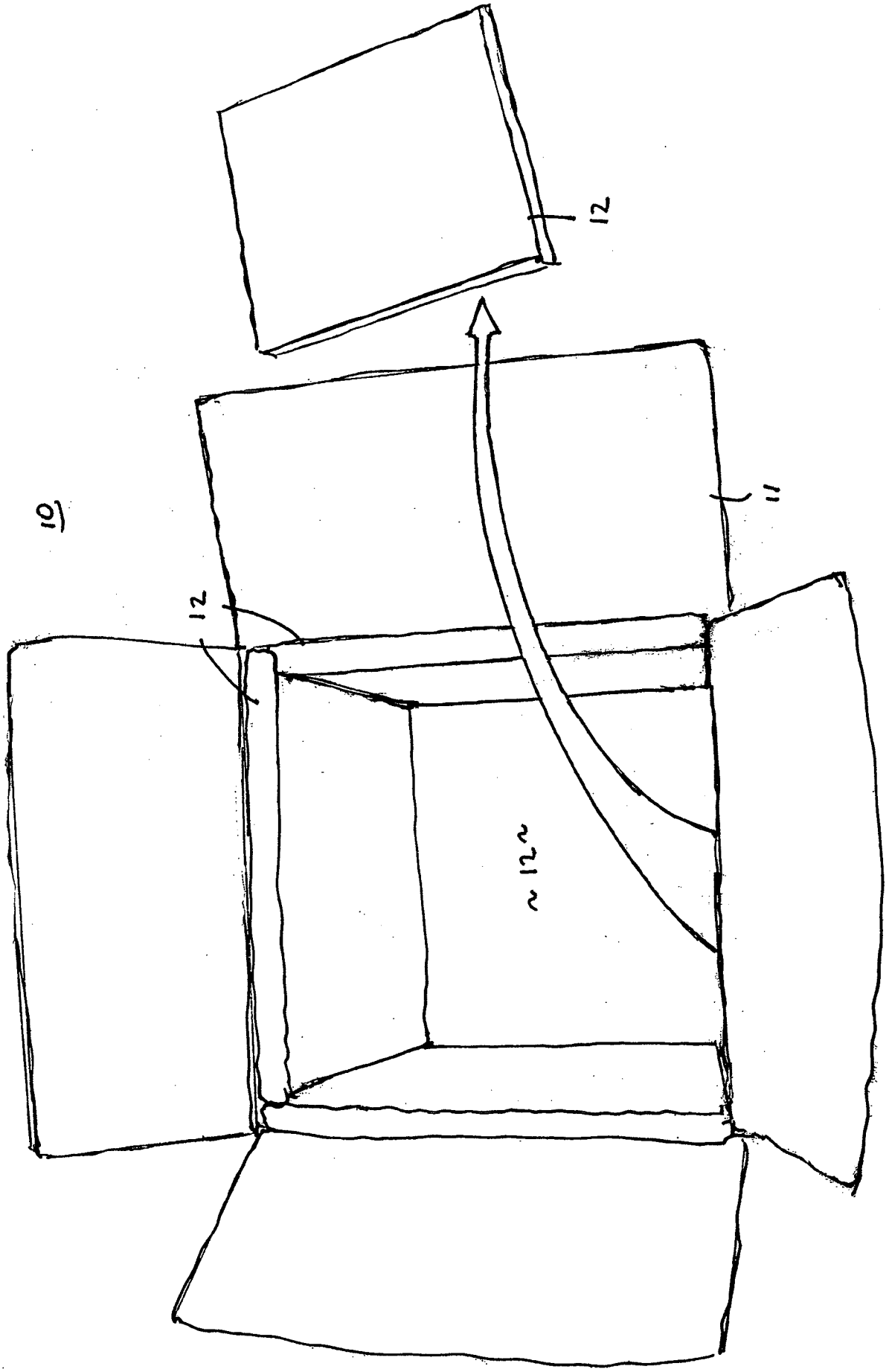

FIG. 6

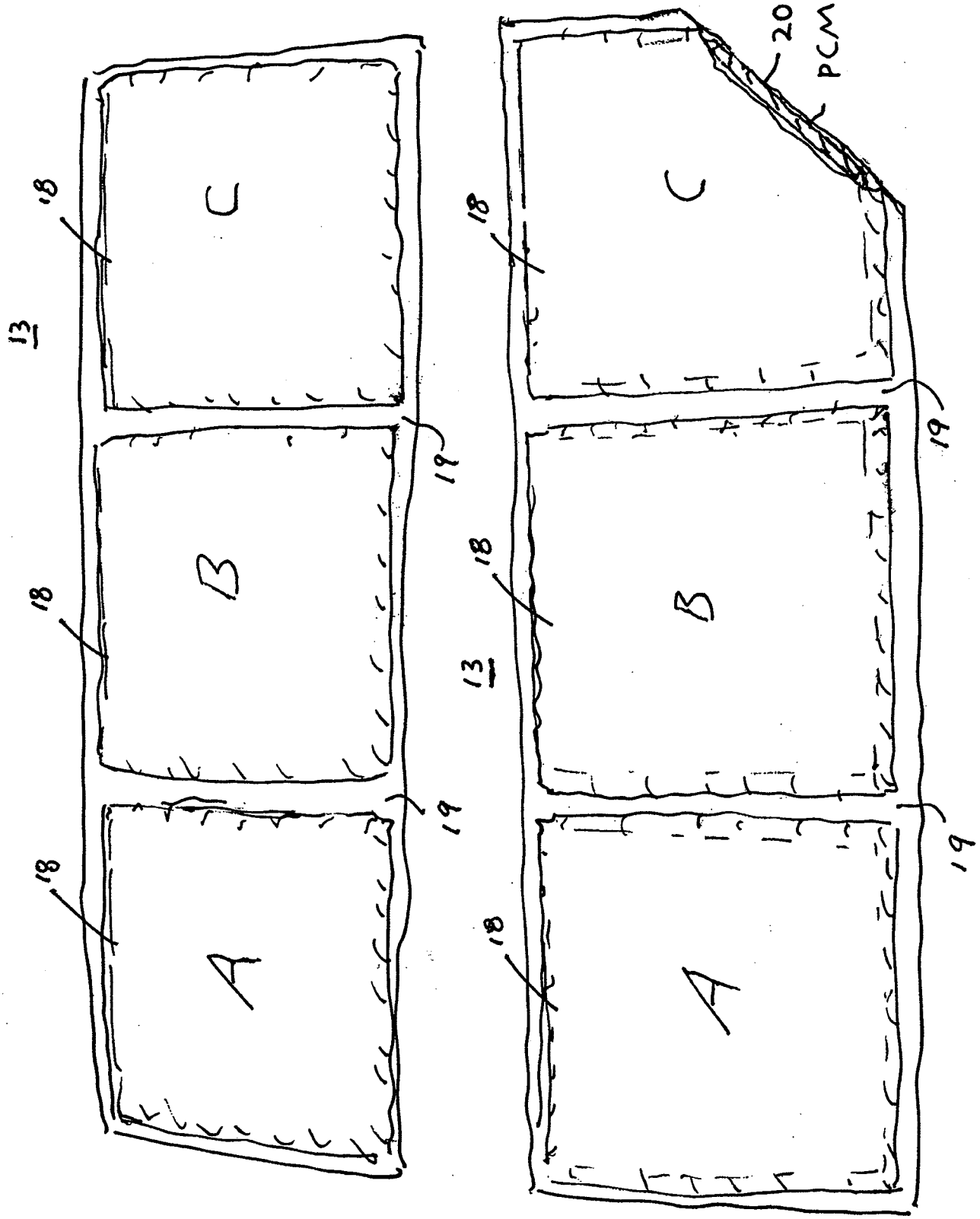

FIG. 7

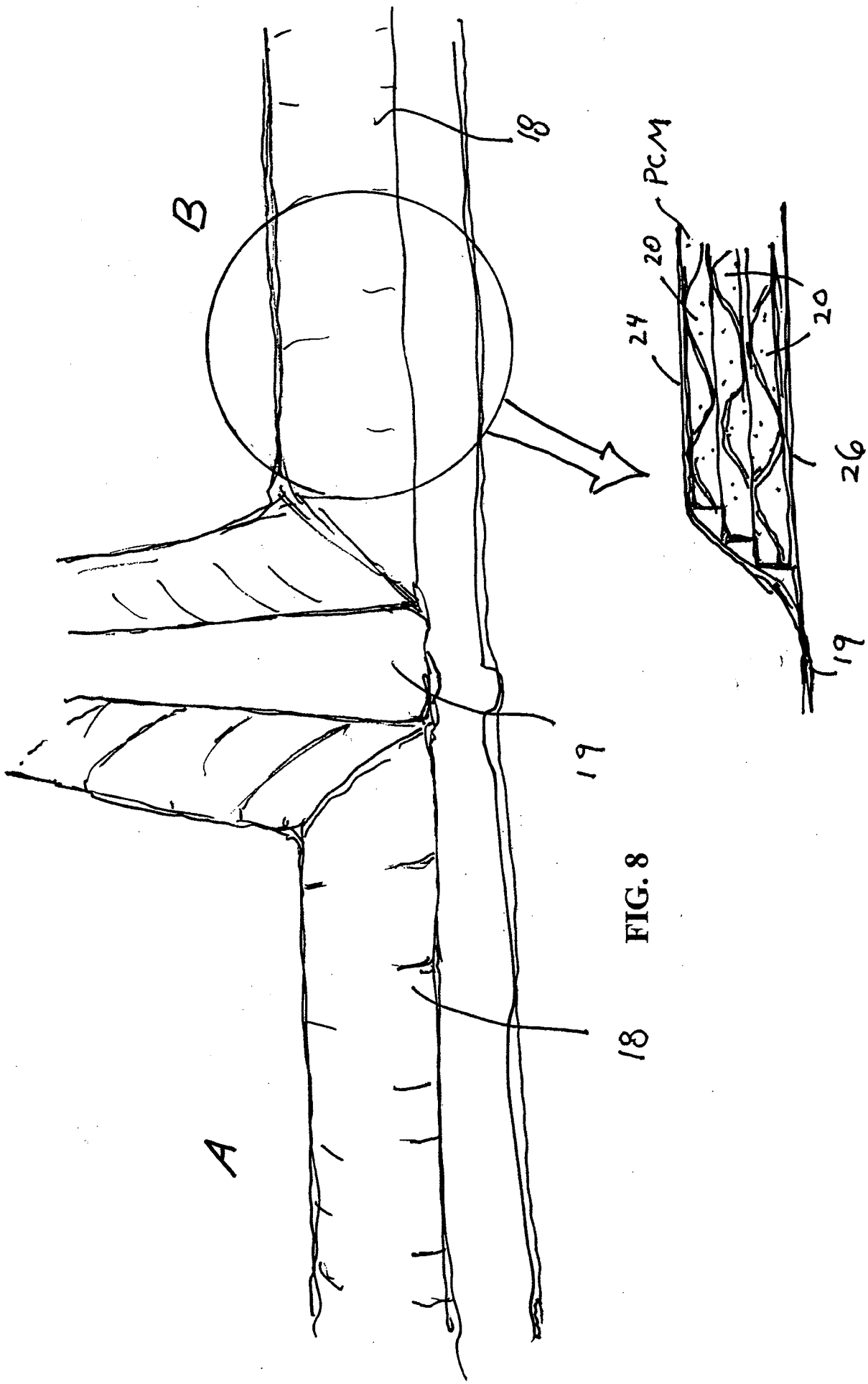

FIG. 8

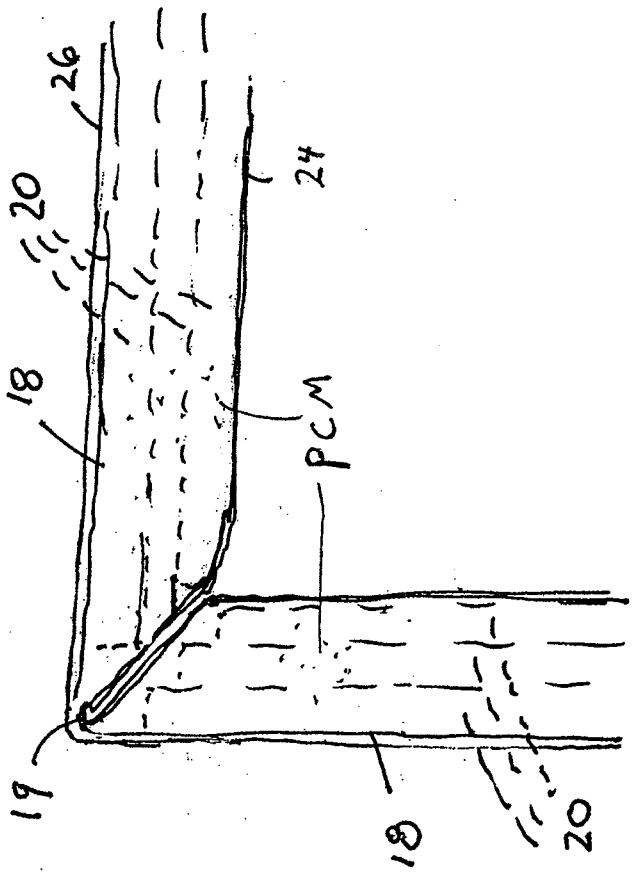

FIG. 10

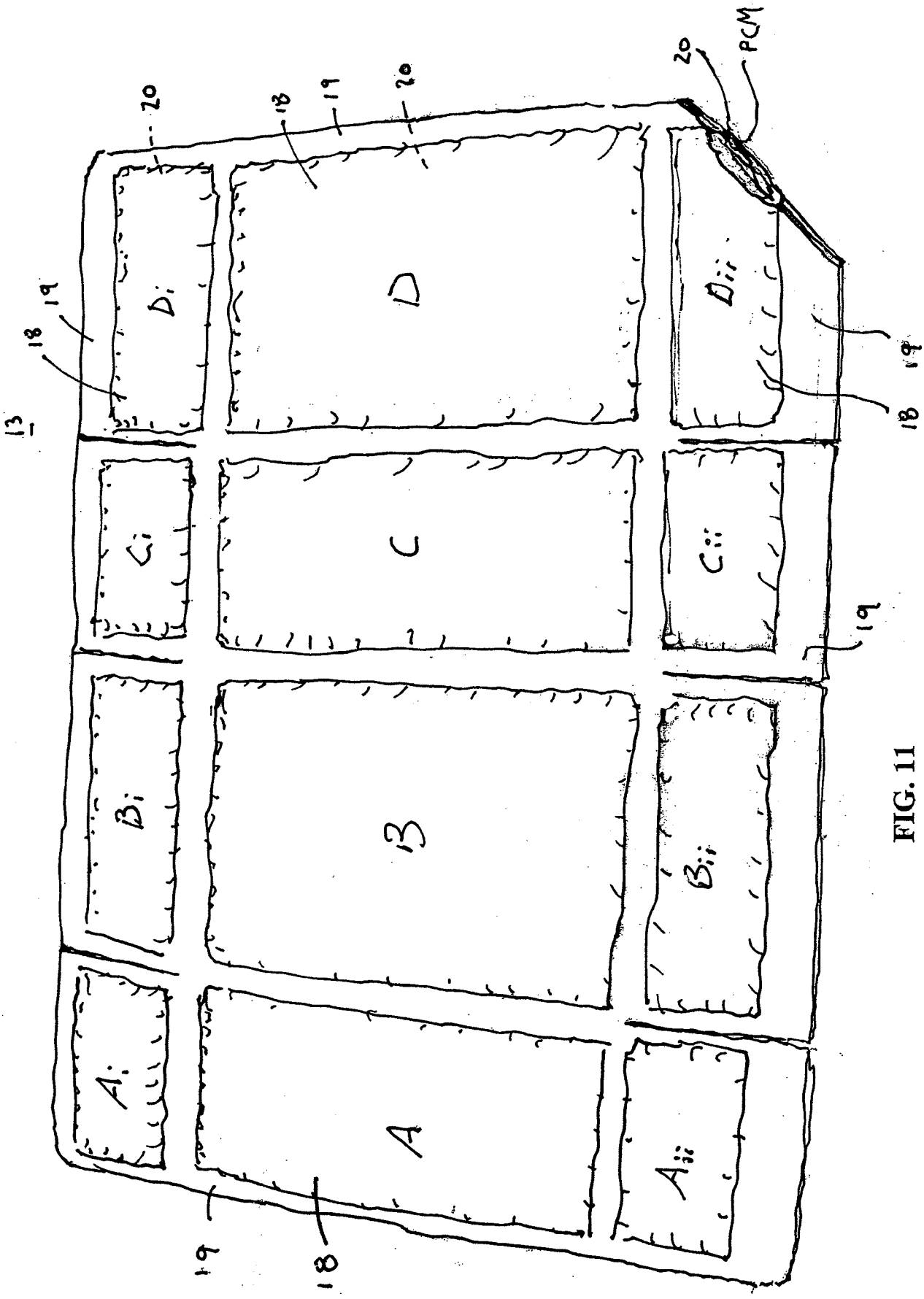

FIG. 11

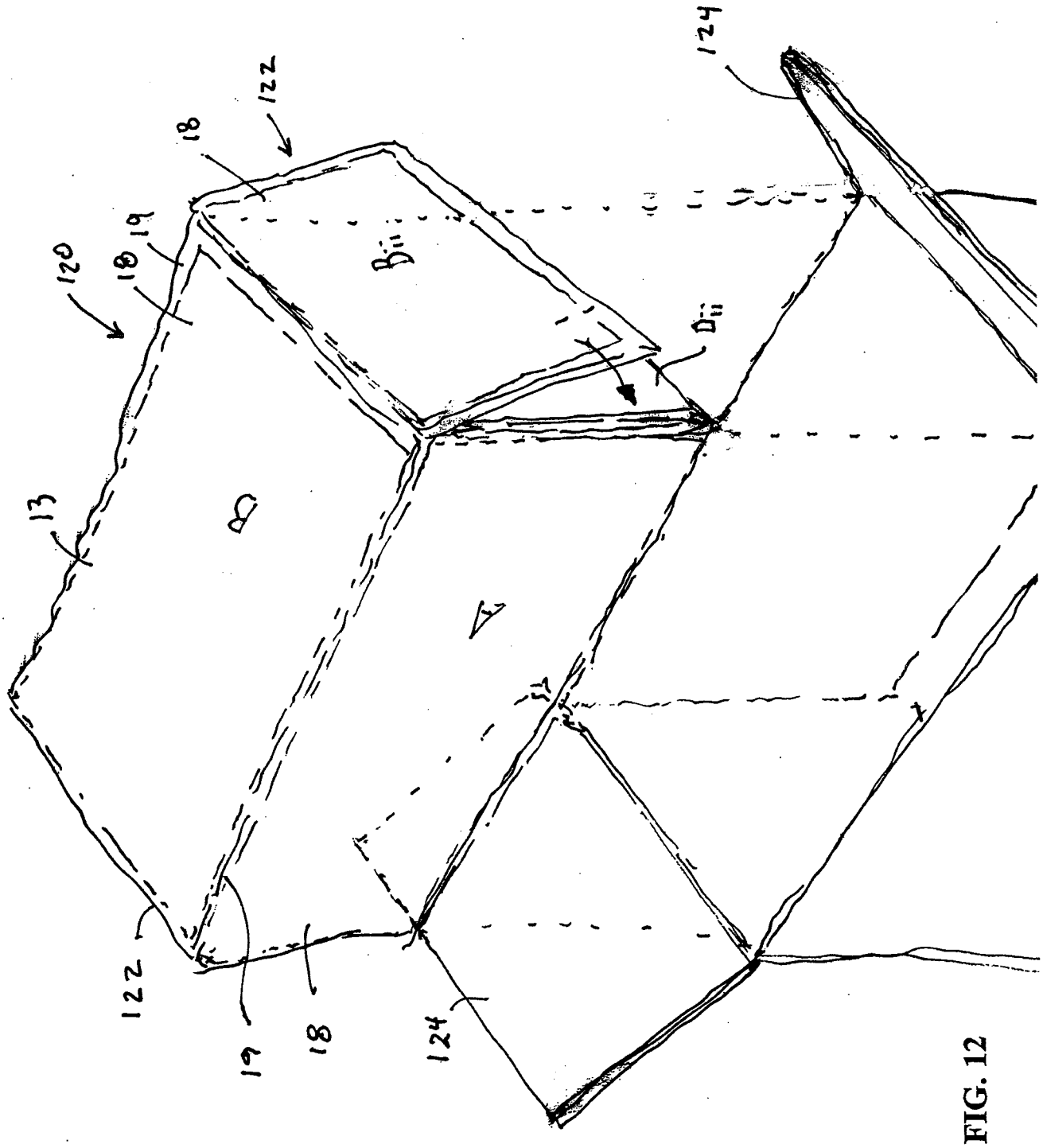

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/034817

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B65D 81/38 (2010.01)
USPC - 220/592.26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B65D 81/38 (2010.01)
USPC - 220/592.2, 592.26, 721, 722

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2008/0164265 A1 (CONFORTI) 10 July 2008 (10.07.2008) entire document	1-13 — 14-20
Y	US 2009/0039088 A1 (WILLIAMS et al) 12 February 2009 (12.02.2009) entire document	14-20

☐ Further documents are listed in the continuation of Box C. ☐

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

Date of the actual completion of the international search	Date of mailing of the international search report
01 July 2010	21 JUL 2010
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)