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(72) Inventors:
• **WU, Guolian**
Benton Harbor, MI Michigan 49022 (US)
• **CUR, Nihat**
Benton Harbor, MI Michigan 49022 (US)

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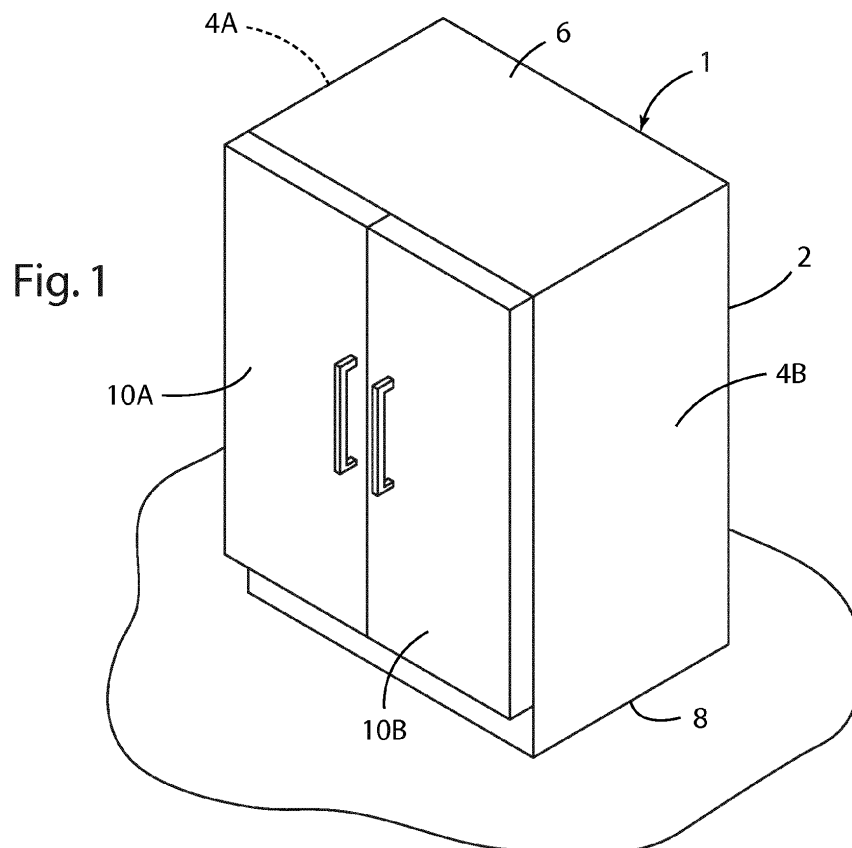
(74) Representative: **Nicholls, Michael John**
J A Kemp
14 South Square
Gray's Inn
London WC1R 5JJ (GB)

(71) Applicant: **Whirlpool Corporation**
Benton Harbor, MI 49022 (US)

(54) **Folded vacuum insulated structure**

(57) A vacuum insulated cabinet structure for refrigerators and the like includes a plurality of vacuum insulated panels. The cabinet structure may include an "O" or "U" structure that is formed by folding a large panel

assembly. The panels may comprise side walls that are heat-sealed together around the perimeters of the panels to form airtight spaces having a vacuum.



Description

[0001] One aspect of the present invention is a vacuum insulated refrigerator cabinet structure. The cabinet structure includes a metal outer layer and a polymer inner layer. The inner and outer layers are spaced apart to form an insulation space. The insulation space is filled with a filler material, and a vacuum is formed in the space. During fabrication, a sheet metal layer is cut to form a blank. The sheet metal layer includes a layer of heat-sealable polymer material that is laminated to a first side of the sheet. A layer of polymer material including an impermeable layer of polymer material such as ethylene vinyl alcohol (EVOH) is heat-sealed to the metal/polymer blank. The resulting structure is then folded to form a cabinet structure having an "O" shape or a "U" shape. Additional insulated panels are then secured to the O or U-shaped primary structure to thereby form an insulated space.

[0002] These and other features, advantages, and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

The present invention will be further described by way of example with reference to the accompanying drawings in which:-

Fig. 1 is an isometric view of a refrigerator having a vacuum insulated cabinet structure according to one aspect of the present invention;

Fig. 2 is an exploded perspective view of a vacuum insulated cabinet structure having a O-shaped primary structure;

Fig. 3 is a cross-sectional view of the vacuum insulated cabinet structure of Fig. 2;

Fig. 4 is an exploded perspective view of an insulated cabinet structure having a U-shaped primary component;

Fig. 5 is an isometric view of a subassembly that is folded to form an O-shaped primary structure;

Fig. 6 is an elevational view of the subassembly of Fig. 5;

Fig. 7 is an isometric view of a O-shaped vacuum insulated primary structure;

Fig. 8 is an isometric view of a subassembly used to fabricate a U-shaped primary vacuum insulated structure;

Fig. 9 is an elevational view of the subassembly of Fig. 8;

Fig. 10 is an isometric view of a U-shaped vacuum insulated primary structure;

Fig. 11 is a cross-sectional view of a portion of the subassemblies of Figs. 6 and 9;

Fig. 12 is a cross-sectional view of a corner of the vacuum insulated primary structures of Figs. 2 and 4;

Fig. 13 is a partially fragmentary enlarged cross-sectional view of a portion of the subassemblies of Figs. 6 and 9;

Fig. 14 is an isometric view of a vacuum insulated cabinet structure according to another aspect of the present invention;

Fig. 15 is a cross-sectional view of the vacuum insulated cabinet structure of Fig. 14; and

Fig. 16 is partially fragmentary enlarged view of a portion of the vacuum insulated cabinet structure of Fig. 15.

[0003] For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the invention as oriented in Fig. 1. However, it is to be understood that the invention may assume various alternative orientations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0004] With reference to Fig. 1, a refrigerator 1 according to one aspect of the present invention includes an insulated cabinet 2 that generally includes vertical side walls 4A and 4B, a horizontal upper wall 6, and a horizontal lower wall 8. Doors 10A and 10B are moveably mounted to the insulated cabinet 2 in a known manner. As discussed in more detail below, refrigerator 1 may include an "O" shaped primary structure 20A (Fig. 2), or it may include a U-shaped primary structure 20B (Fig. 4).

[0005] With reference to Fig. 2, O-shaped primary structure 20A defines enlarged front and rear openings 12 and 14, respectively. Doors 10A and 10B selectively close off the front opening 12, and a rear panel assembly 16 may be utilized to close off rear opening 14. Rear panel assembly 16 may include a vertical panel 18, and a horizontal divider 22 and/or a vertical divider 24. The divider 22 (or 24) may include a cooling module that cools the insulated space on opposite sides of the divider 22 (or 24). Examples of suitable cooling modules are disclosed in U.S. Patent Application No. 13/108,226 entitled "COOLING SYSTEM INTEGRATION ENABLING PLATFORM ARCHITECTURE" filed on May 16, 2011; U.S. Patent Application No. 13/108,293 entitled "FLEXIBLE COOLING SYSTEM INTEGRATION FOR MULTIPLE PLATFORMS" filed on May 16, 2011; and U.S. Patent Application No. 13/108,183 entitled "UNIVERSAL AND FLEXIBLE COOLING MODULE SET (CMS) CONFIGURATION AND ARCHITECTURE" filed on May 16, 2011. Each of these applications is hereby incorporated herein by reference in their entirety.

[0006] As discussed in more detail below, primary structure 20A includes an outer skin 26 and an inner skin 28. The outer skin 26 comprises a layer of sheet metal (e.g. low carbon steel) having a layer of heat-sealable

polymer material laminated to one side of the layer of metal. Inner skin 28 comprises a layer of thermoplastic polymer such as high impact styrene and a barrier layer that may comprise polymer material such as ethylene vinyl alcohol (EVOH). The barrier layer forms a barrier with respect to gasses and water vapor. The polymer inner skin 28 is sealed to the polymer material of the outer skin 26 to form an insulation space 30 (Fig. 3). The polymer inner skin 28 is may be sealed to the polymer material of the outer skin 26 utilizing a heat seal process that softens or partially melts the polymer material of the skin 26 and/or skin 28. Heat can be generated using one or more conventional electrical resistance heating elements (not shown), or heat can be generated using ultrasonic processes. Mechanical pressure can also be used to seal the skins 26 and 28 together. Still further, adhesive or other suitable material can also be used to connect/seal skins 26 and 28 together. Powdered silica or other filler material 32 is disposed in the insulation space 30, and a vacuum is formed in the insulation space 30 to thereby provide a vacuum insulated structure. Openings or valves 34 and 36 may be utilized to blow the filler material 32 into the space 32 prior to forming a vacuum. The primary structure 20A may be placed in a vacuum chamber, and openings or valves 34 and 36 may then be closed to form a vacuum in the insulation space 30. Alternatively, as discussed in more detail below, the filler material 32 may be positioned in the insulation space 30 prior to interconnection of outer skin 26 and inner skin 28. The skins 26 and 28 sealed together in a vacuum chamber to form a vacuum in insulation space 30. If this process is utilized, the openings or valves 34 and 36 are not required.

[0007] With further reference to Fig. 4, a primary cabinet structure 20B according to another aspect of a present invention is substantially U-shaped, with side walls 4A and 4B extending from a rear wall 38. Upper and lower side walls 6A and 8A may comprise separate panels that are secured to the primary structure 20B to form an insulated space 44B. As discussed in more detail below, the primary structure 20B includes a metal outer skin 26 and a polymer inner skin 28 that are heat sealed together to form a vacuum in substantially the same manner as primary structure 20A. The upper side wall 6A or lower side wall 8A may include a cooling module as described above in connection with dividers 22 and 24. An outer optional cover 46 having side walls 48A-48D (and optionally 48E) may be utilized to form an outer decorative surface of the refrigerator to cover, for example, the joints between primary structure 20B and upper and lower walls 6A and 6B, respectively. The outer cover 46 is optional. A refrigerator including the primary structure 20A of Fig. 2 may also include an outer cover 46. A polymer liner 50 may also be disposed with the primary structure 20B. Polyurethane foam or the like may be injected into spaces between primary structure 20B and liner 50 to provide support for the polymer liner 50. The polymer liner 50 may include various features such as

shelf supports 52A-52C that support shelves 54.

[0008] With further reference to Figs. 5-7, O-shaped primary structure 20A is formed from a subassembly 56 that is folded along lines 58A-58C. The inner skin 28 may comprise a composite sheet having a layer of thermoplastic polymer material such as high impact polystyrene that is laminated to a thin barrier layer of polymer material. The thin barrier layer may comprise EVOH or other material (e.g. metal foil) capable of maintaining a vacuum in insulation space 30 for the life of the insulated cabinet structure. For example, the barrier layer may be selected such that the thermal conductivity of the vacuum insulated structure does not exceed 200% of its initial value for at least 10 years.

[0009] With further reference to Fig. 11, the outer skin 26 may comprise a metal sheet 62. Metal sheet 62 may comprise low carbon steel or the like having a pre-painted outer surface 66. Outer skin 26 includes a layer of heat-sealable polymer material 64 that is laminated to the metal 62. The inner skin 28 may be thermoformed to form elongated shaped grooves 70A-70C having angled side walls 72A and 72B. The grooves 70 may include a flat side wall portion 74 extending between side walls 72A and 72B. The lower surface 76 of flat side wall portion 74 may be spaced apart from surface 78 of heat-sealable plastic 64 to form a gap "G". Alternately, the lower surface 76 may be in contact with surface 78, and a seal may be formed between the surfaces 76 and 78. Also, the angled side walls may form a "sharp" V 74A if groove 70 includes a side wall 72C as shown in dashed lines.

[0010] With further reference to Fig. 13, the outer skin 26 and inner skin 28 may be interconnected along the opposite side edges 68A and 68B of subassembly 56. Inner skin 26 may include an outwardly extending flange 80 that is heat-sealed to the polymer material 64 of outer skin 26 along edge 82 of outer skin 26.

[0011] Referring again to Figs. 6 and 7, ends 60A and 60B of subassembly 56 may be angled at a 45 degree angle and joined together at a corner 84. Alternatively, the ends of 60A and 60B may be orthogonal, and joined along a center seam 86. If a seam 86 is utilized, the ends 60A and 60B may have a configuration that is substantially similar to the configuration of edges 68A and 68B (Fig. 13). When assembled, polyurethane foam 88 (Fig. 12) can be injected to fill gaps between polymer liner 50 and inner skin 28 and between ends 60A and 60B. Also, side wall 90 (Fig. 13) of inner skin 28 may be angled or beveled in a manner similar to the angled side walls 72A and 72B (Fig. 11) along one or both side edges 68A, 68B to provide an angled front edge 92A (Fig. 7) and/or angled rear edge 92B. Edges 94 of panel 18 (Fig. 2) may be beveled to fit closely with beveled or angled rear edges 92B of primary structure 20A. Polyurethane foam 88 (Fig. 12) may be injected between liner 50 and inner skin 28 to fill gaps at the joints between edge 92B of primary structure 20A and vertical panel 18.

[0012] Referring again to Fig. 5, during fabrication of primary structure 20A, a sheet of metal/plastic is cut to

form a blank 126 having generally rectangular perimeter 96. As discussed above, skin 28 comprises a thermoplastic polymer material such as a high impact polystyrene that is laminated to a relatively thin layer of EVOH or other suitable barrier material. It will be understood that the skin 28 may comprise multiple layers of material, and the EVOH layer may be sandwiched between adjacent layers of thermoplastic polymer material. The polymer material of the inner skin 28 is thermoformed utilizing known processes and tools to form a polymer blank 128 that includes the grooves 70A and 70C and side walls 90 (Fig. 13) and flanges 80. The polymer blank 128 is then positioned on the outer blank 126. The filler material 32 may be positioned in cavities 30 prior to positioning polymer blank 128 on metal blank 126. For example, one or more pouches 33 containing filler material 32 may be placed on metal blank 126. The pouches 33 may comprise a single elongated pouch having a generally rectangular perimeter that is positioned adjacent rectangular parameter 96 of outer skin blank 126. Alternately, a plurality of individual pouches 33 having shapes corresponding to individual panel sections 98A-98C may be positioned on the metal blank 126. The pouches 33 may comprise an outer layer of paper or other permeable material 35 that permits airflow, but retains filler material 32. If a single elongated pouch 33 is utilized, the pouch may be compressed at the V-grooves 70A-70C such that the regions of the pouch 33 in the vicinity of the gap G (Fig. 11) are thin. Alternately, if a plurality of individual pouches 33 are utilized, the polymer blank 128 can be sealed to outer skin blank 126 along the V-grooves 70.

[0013] After placing polymer blank 128 over pouches 33 on metal blank 126, the metal blank 126 and polymer 128 are then positioned in a vacuum chamber (not shown). The polymer blank 128 is sealed to polymer material 64 of outer skin blank 126 along flanges 80 to thereby form an air-tight seal around insulation spaces 30. The polymer blank 128 is also sealed to metal blank 126 at V-grooves 70 if necessary for a particular application. The entire perimeter 96 of subassembly 56 can be sealed in the vacuum chamber. Alternately, a portion of the rectangular perimeter 96 may be sealed prior to positioning the blanks 126 and 128 in the vacuum chamber, and the remaining portion of the perimeter 96 can be sealed in the vacuum chamber. Also, a plurality of the subassemblies 56 can be positioned in a single vacuum chamber in a stacked relationship, and the blanks 126 and 128 of the subassemblies 56 can be sealed in the vacuum chamber. As discussed above, the blanks 126 and 128 can be connected/sealed utilizing a heat seal process, mechanical pressure, adhesives, or other suitable processes/materials.

[0014] After the subassembly 56 is removed from the vacuum chamber, it can be folded along the V-grooves 70A-70C to form a primary structure 20A (Fig. 7). The ends 60A and 60B can be adhesively interconnected or otherwise secured together. A forming tool (not shown) can be positioned in the V-grooves 70A-70C during the

bending process. Also, the blank 56 may optionally be heated in the vicinity of V-grooves 70A-70C to facilitate bending at the grooves 70A-70C. The rear panel assembly 16 may then be secured to the primary structure 20A (Fig. 2). A polymer liner 50 may optionally be inserted into the primary structure 20A, and polyurethane foam 88 may be injected into the space 89 between inner skin 28 and polymer liner 50.

[0015] The filler material 32 may be positioned between the metal blank 126 and polymer blank 128 prior to the sealing operation as just described. Alternately, the outer metal blank 126 may be sealed to the polymer blank 128 under atmospheric conditions. The subassembly 56 can then be folded to form primary structure 20A. The filler material 32 can then be blown into the spaces 30 utilizing one or more openings or valves 34 and 36 (Fig. 2). For example, a filter (not shown) may be placed over opening 36, and filler material 32 may be blown into the spaces 30 utilizing opening 34. The filter over opening 36 permits air to flow out of the internal space 30, thereby compacting the filler material 32 in spaces 30. The primary structure 20A can then be placed in a vacuum chamber, and the openings 34 and 36 can then be closed off. The structure 20A can be moved from the vacuum chamber. It will be understood that each panel section 98A-98C (Fig. 5) may include both an inlet opening 34 and an outlet opening 36 if filler material 32 is blown into spaces 30 after folding blanks 56.

[0016] With further reference to Figs 8-10, a U-shaped primary structure 20B (see also Fig. 4) may be formed utilizing a metal blank 126A and a polymer blank 128A in substantially the same manner as described above in connection with Figs 5-7. The polymer blank 128 includes three panel sections 98A-98C corresponding to the three side walls 4A, 38 and 4B of U-shaped primary structure 20B (Fig. 10). After formation of primary structure 20B, an upper wall 6A and lower wall 8A are secured to the U-shaped primary structure 20B (Fig. 4). The side wall 90 (Fig. 13) along side edges 68A and 68B (Fig. 8) of inner skin blank 128 may be angled at, for example, a 45 degree angle (i.e. similar to side wall 72B of Fig. 11), such that upper edges 5A-5C (Fig. 10) and lower edges 11A-11C of primary structure 20B are beveled or angled. Similarly, side edges 7A-7C of upper wall 6A (Fig. 4) and edges 9A-9C of lower wall 8A may also be beveled. Thus, when assembled, the edges 7A-7C of upper wall 6A fit closely against upper edges 5A-5C of primary structure 20B, and side edges 9A-9C of lower wall 8A fit closely in side edges 11A-11C of U-shaped primary structure 20B. Polyurethane foam 88 (Fig. 12) can be utilized to fill any spaces that may exist at the joints formed between upper wall 6A and primary structure 20B, as well as gaps at joints between lower wall 8A and primary structure 20B.

[0017] With further reference to Figs 14-16, a vacuum insulated cabinet 102 according to another aspect of the present invention includes an inner member 104, and an outer member 106. Inner member 104 may comprise a one-piece metal structure having including integrally

formed side walls 108A-108E, and outer member 106 may comprise a one-piece metal member having side walls 110A-110E. In general, inner and outer members 104 and 106 may both be formed from a single piece of sheet metal utilizing a drawing process, or one or both of the inner and outer members 104 and 106 may be thermoformed from a sheet of polymer material. If inner member 104 or outer member 106 is formed of a polymer material, the polymer material preferably includes a barrier layer such as EVOH or metal foil, and one or more layers of thermoplastic material.

[0018] After inner member 104 and outer member 106 are formed, inner member 104 is positioned inside outer member 106, and an elongated edge member 112 is connected to the inner member 104 and outer member 106 along edges 114 and 116 to thereby form a space 118 between inner member 104 and outer member 106. The edge member 112 may comprise an extruded polymer material, and preferably includes one or more layers of impermeable material such as EVOH and layers of regions of thermoplastic polymer material. The edge member 112 may be sealingly connected to the edges 114 and 116 utilizing adhesive sealant or other suitable material. Also, inner member 104 and/or outer member 106 may comprise a metal sheet having a layer of heat-sealable polymer material laminated to a side face of the material, and the edges 114 and 116 may be heat-sealed to edge member 112. Alternately, inner member 104 and/or outer member 106 may comprise a polymer material and the edges 114 and 116 can be heat-sealed to edge member 112. If inner member 104 and outer member 106 comprise sheet metal, the edge member 112 provides a thermal break, thereby reducing or preventing conductive heat transfer between inner member 104 and outer member 106.

[0019] Filler material 120 is disposed in insulating space 118. The filler material may comprise silica or other porous material capable of supporting the inner and outer members 104 and 106 when a vacuum is formed in the insulating space 118.

[0020] During assembly, the inner member 104, outer member 106, and edge member 112 may be positioned in a vacuum chamber, and filler material 120 may be disposed and compacted in space 118. The edge member 112 may then be sealingly connected to the inner member 104 and outer member 106, and the cabinet 102 can then be removed from the vacuum chamber. Alternately, one or more openings or valves 34 and 36 (Fig. 2) can be utilized to blow filler material 120 into insulating space 118, and the openings can then be sealed off before removal of the cabinet 102 from a vacuum chamber

Claims

1. A method of forming a vacuum insulated cabinet structure, the method comprising:

forming a generally rectangular first blank from a sheet of material that includes a metal layer and a thermoplastic polymer layer;
forming a generally rectangular second blank from a sheet of material that includes a layer of thermoplastic polymer material and a layer of material that is substantially impermeable, wherein the second blank includes a plurality of shallow pockets that open towards a first side of the second blank, the second blank including at least one groove extending between opposite side edges of the second blank to form a divider between adjacent shallow pockets;
positioning the first and second blanks directly adjacent one another such that the first blank substantially closes off the shallow pockets;
providing a porous filler material in the pockets;
positioning the first and second blanks in a vacuum chamber;
sealing the second blank to the thermoplastic layer of the first blank such that the shallow pockets form sealed vacuum spaces;
folding the first and second blanks along the groove.

2. The method of claim 1, wherein at least one of:

- (a) the second blank comprises a layer of EVOH material; and
- (b) the metal layer comprises low carbon steel.

3. The method of claim 1 or 2, wherein:

the second blank includes a generally rectangular perimeter and an outwardly-extending flange at the perimeter.

4. The method of claim 3, including:

heat-sealing the flange to the thermoplastic polymer layer of the first blank.

5. The method of claim 1, wherein either:

- (a) the second blank is sealed to the first blank along the groove; or (b) the second blank includes a plurality of generally planar die wall portions having substantially rectangular perimeters, and optionally the second blank includes edge wall portions extending at approximately 45 degree angles relative to the generally planar side wall portions to define the groove.

6. The method according to any one of the preceding claims, wherein:

the second blank includes first and second grooves extending between opposite side edges

es of the second blank;
the first and second blanks are folded along the first and second grooves to form a generally U-shaped primary cabinet structure.

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7. The method of claim 6, wherein:

the cabinet structure defines upper and lower U-shaped opposite side edges; and including:

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securing an upper insulated panel to the upper side edge;
securing a lower insulated panel to the lower side edge to thereby define a cabinet structure having an inner side surface facing an enlarged interior space.

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8. The method of claim 7, including:

forming a polymer liner;
positioning the liner in the enlarged interior space;
providing thermosetting form insulation between the polymer liner and the inner side surface of the cabinet structure.

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9. The method of claim 7, including:

providing at least one of the upper and lower insulated panels with a powered cooling module that cools the enlarged interior space.

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10. The method according to any one of the preceding claims, wherein:

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the first and second blanks each include first and second opposite ends; and including:

forming at least three grooves in the second blank;
folding the first and second blanks in at least three places to form four side walls, including first and second upright side walls and vertically spaced apart upper and lower side walls extending between the first and second upright side walls;
connecting the first and second opposite ends of the first and second blanks together to form a primary cabinet structure having vertically enlarged front and rear openings.

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11. The method of claim 10, including:

securing an insulated panel to the primary cabinet structure to close off the rear opening and form an insulated space, optionally the method including:

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positioning a divider in the insulated space to form first and second compartments, wherein the divider includes a cooling module that cools the first and second compartments.

12. A method of forming a vacuum insulated cabinet structure, the method comprising:

forming inner and outer shells, the inner and outer shells defining vertical side walls having front and rear edges, horizontal upper and lower side walls having front and rear edges, and extending between the side walls, and a generally vertical rear wall extending between the rear edges of vertical side walls and the upper and lower side walls, whereby the inner and outer shells define generally rectangular front edges;
positioning the inner shell inside the outer shell with the rectangular front edges of the inner and outer shells spaced apart to define an annular space therebetween;
filling the space between the inner and outer shells with a porous filler material;
forming an elongated cap member that forms a sufficient barrier with respect to gasses and water vapor to maintain a vacuum, and wherein the cap member substantially inhibits conductive heat transfer through the cap member;
sealing the elongated cap member to the front edges of the inner and outer shells to form an air-tight insulating space between the inner and outer shells; and
forming a vacuum in the insulating space.

13. The method of claim 12, wherein:

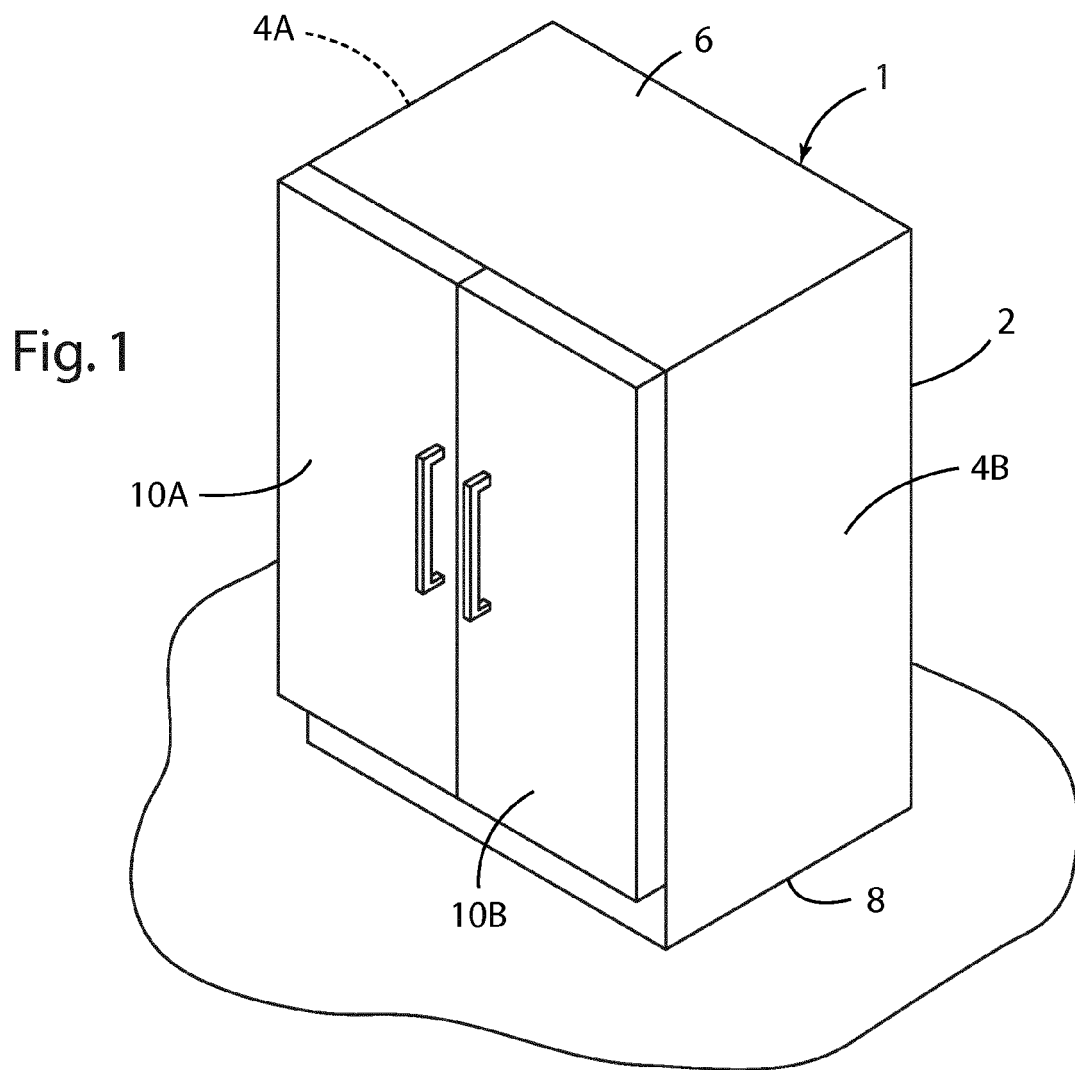
at least one of the inner and outer shells comprises sheet metal.

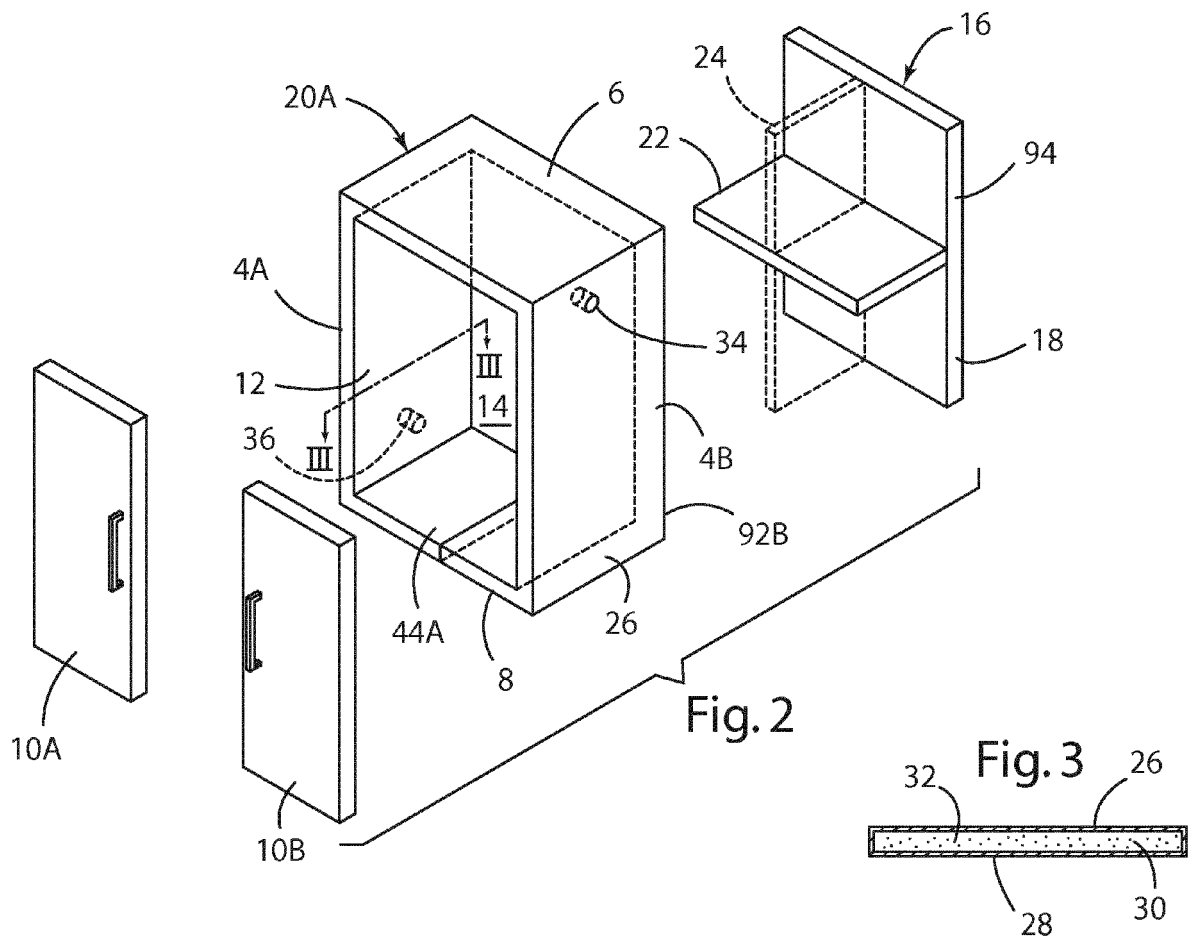
14. The method of claim 12 or 13, wherein:

the elongated cap member comprises a thermoplastic polymer having an barrier layer; optionally comprising EVOH, disposed in the thermoplastic polymer material.

15. The method of claim 12, 13 or 14, wherein:

the elongated cap member forms a continuous ring including four generally linear portions that are joined at four corner portions.





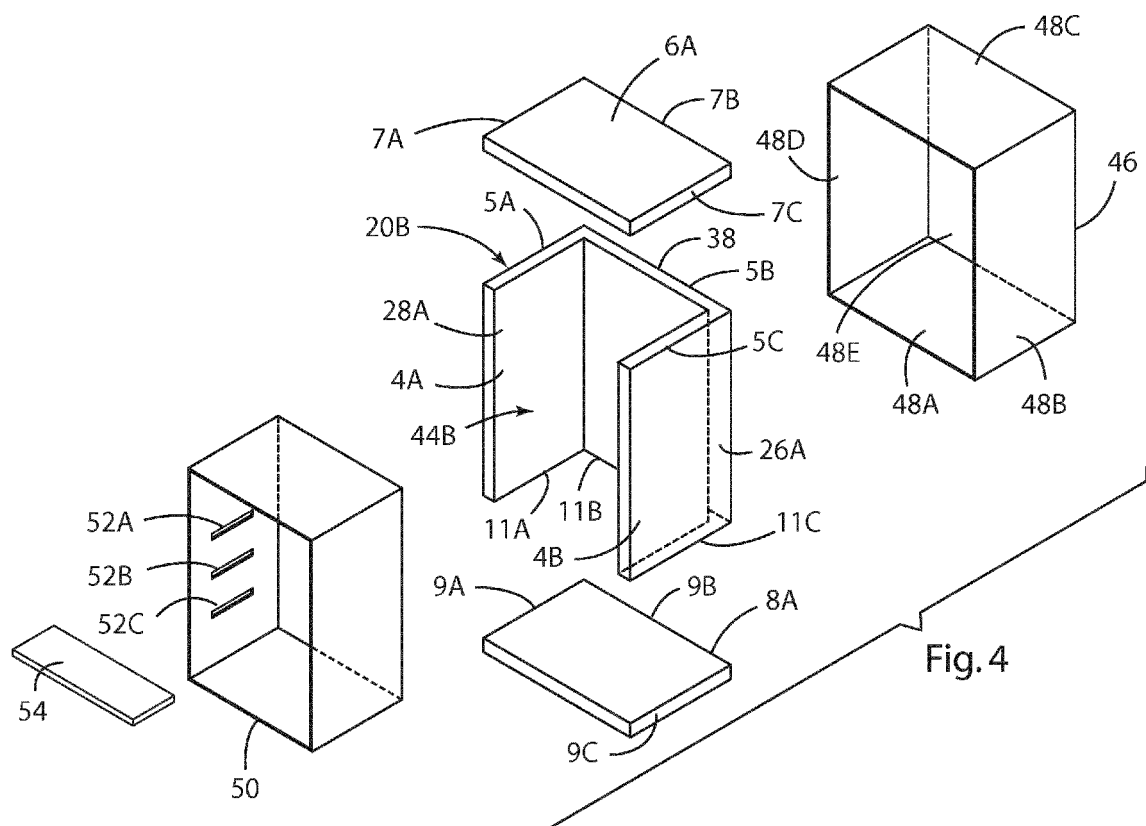
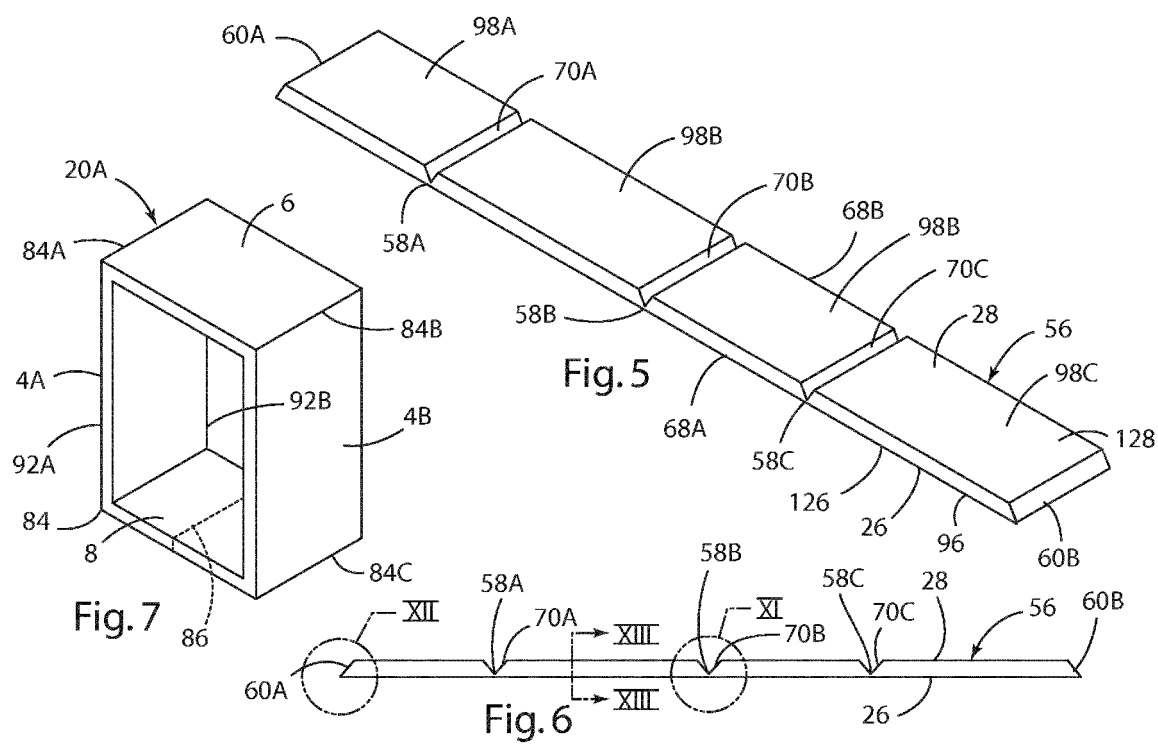
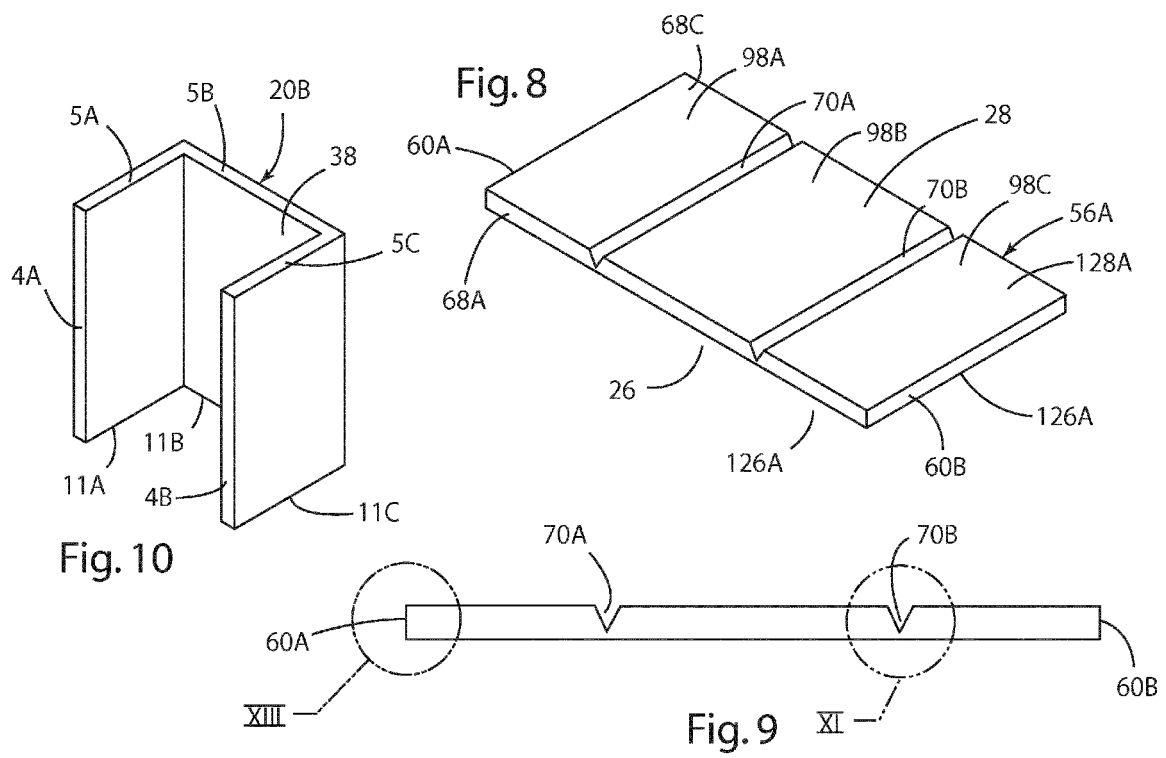


Fig. 4





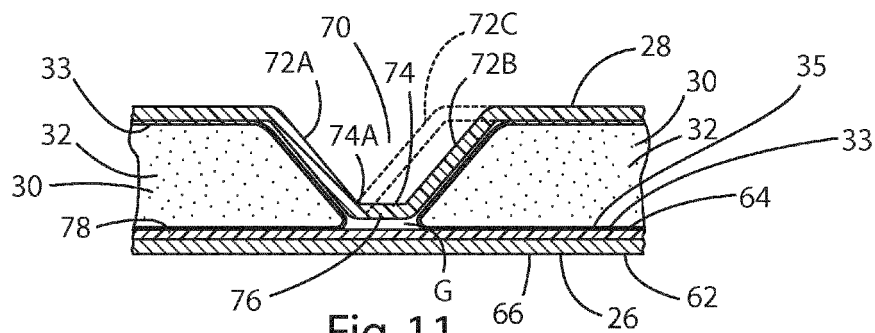


Fig. 11

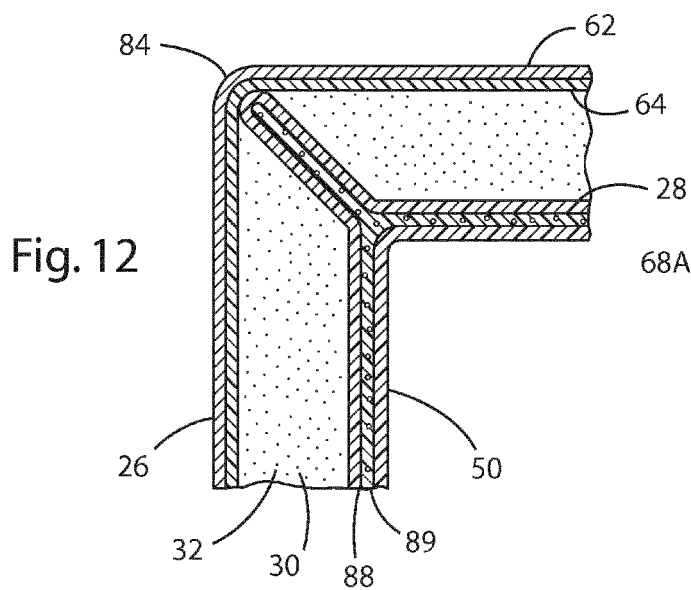


Fig. 12

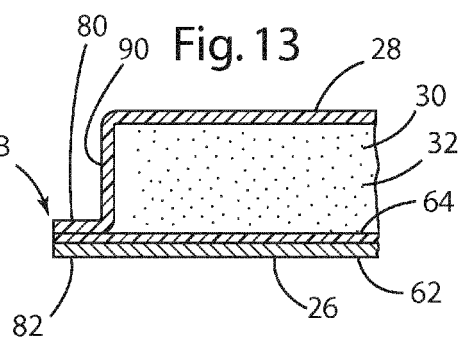
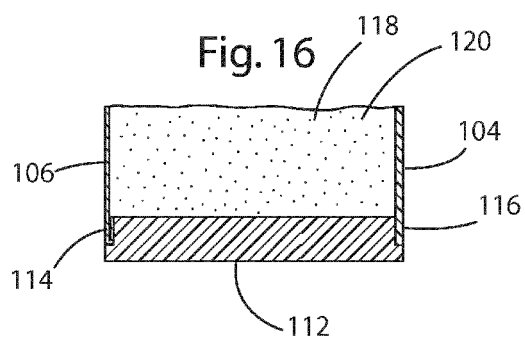
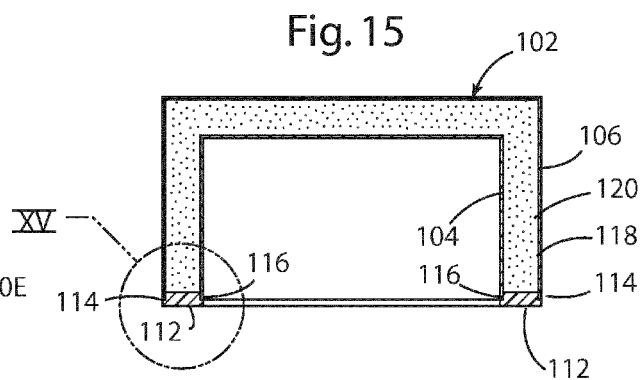
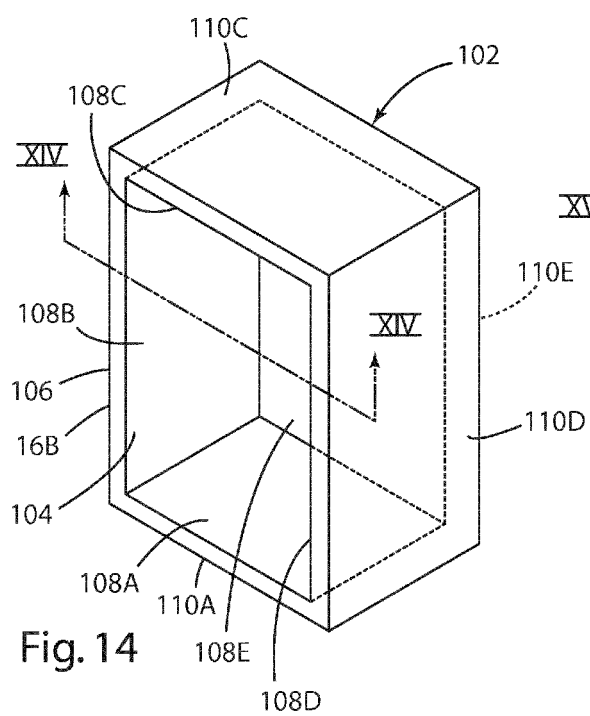


Fig. 13



REFERENCES CITED IN THE DESCRIPTION

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