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(54) **ENERGY ABSORBING COMPONENT FOR BATTERY ENCLOSURE**

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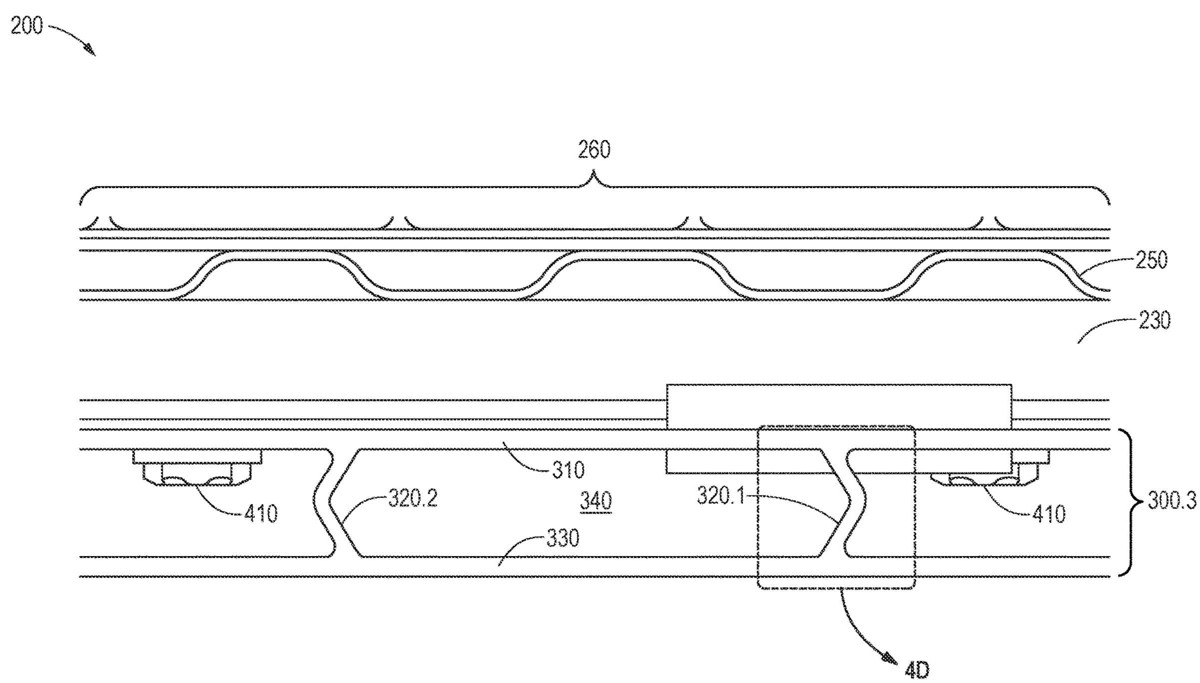
(57) **ABSTRACT**

Certain embodiments provide an energy absorbing component for a battery enclosure that includes collapsible ribs disposed between a first member and a second member of a battery enclosure. The collapsible ribs are configured to deform to absorb impact energy. Each collapsible rib includes a first portion joined to the first member, and a second portion joined to the second member. The first portion has a first thickness, and the second portion has a second thickness that is different than the first thickness.



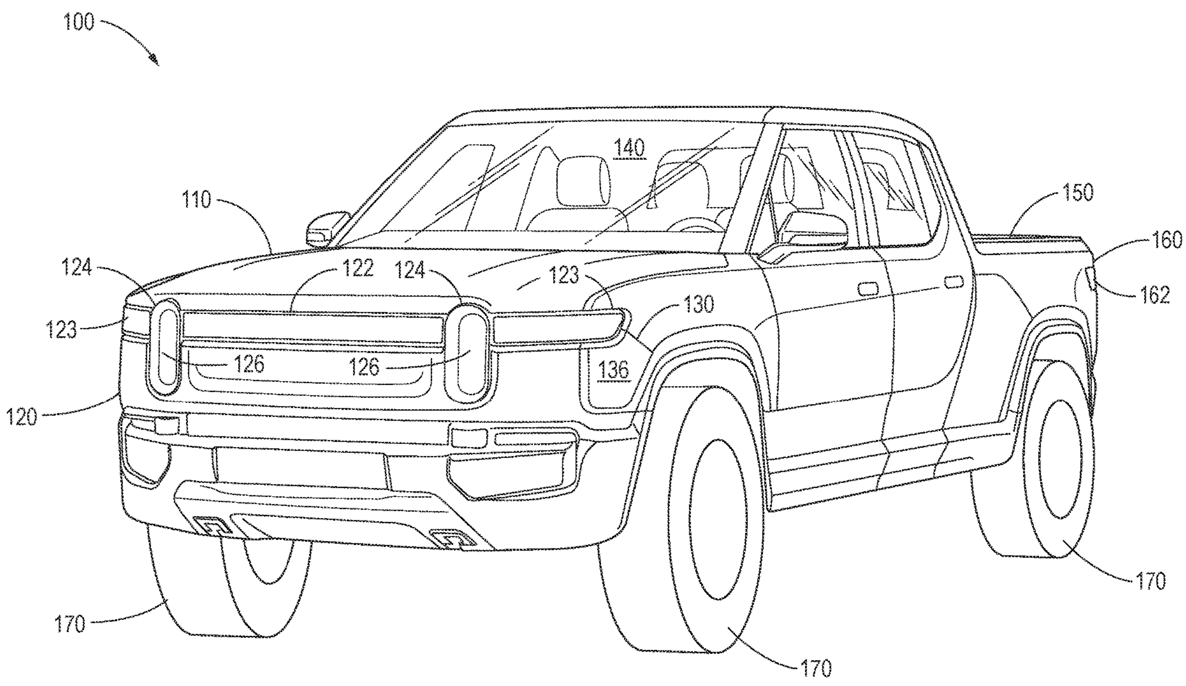

100
110
124
122
124
123
140
150
160
162
123
130
123
126
126
136
120
170
170
170

FIG. 1

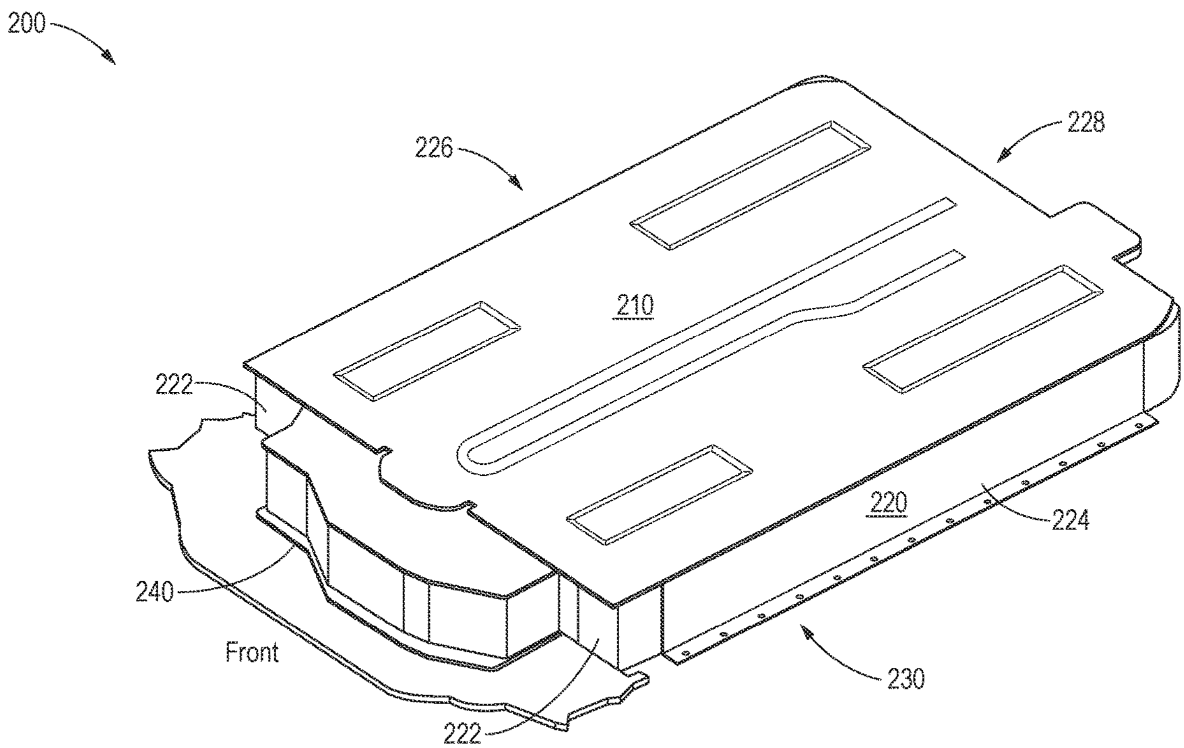


FIG. 2

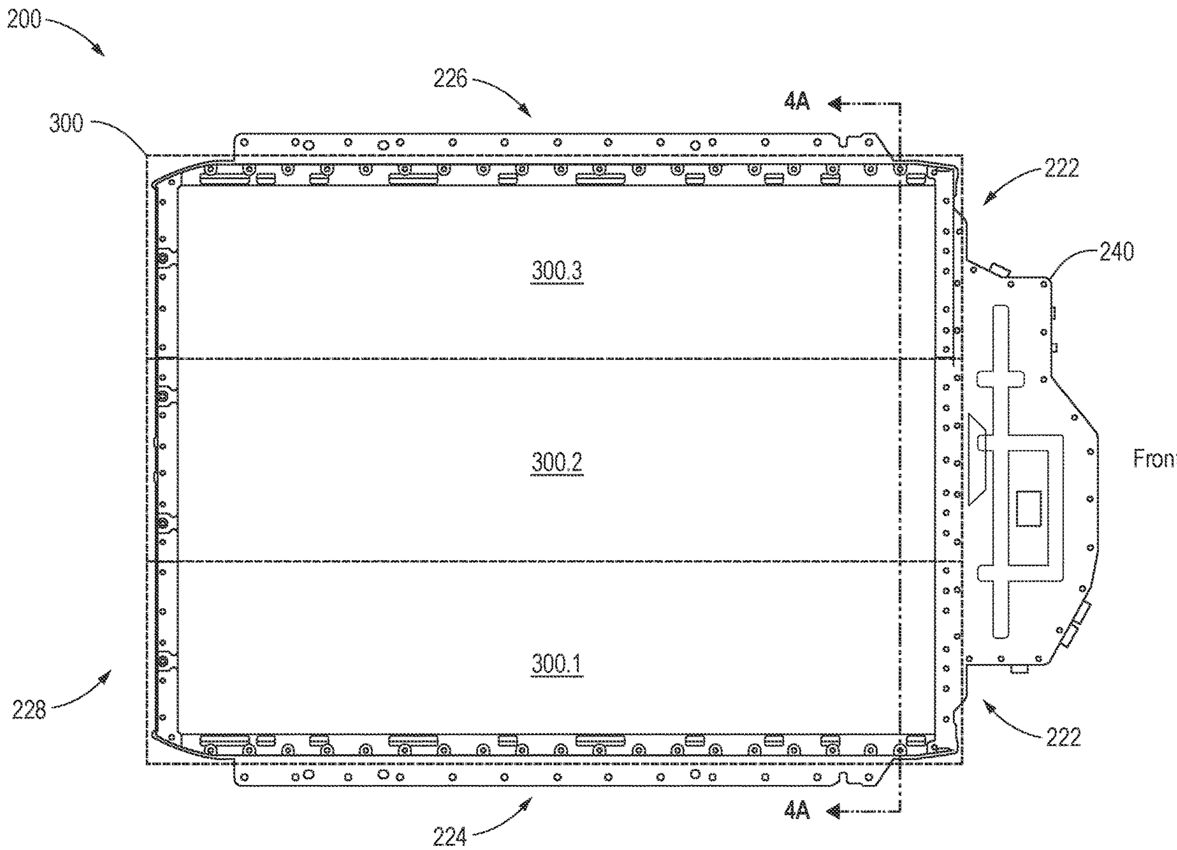


FIG. 3

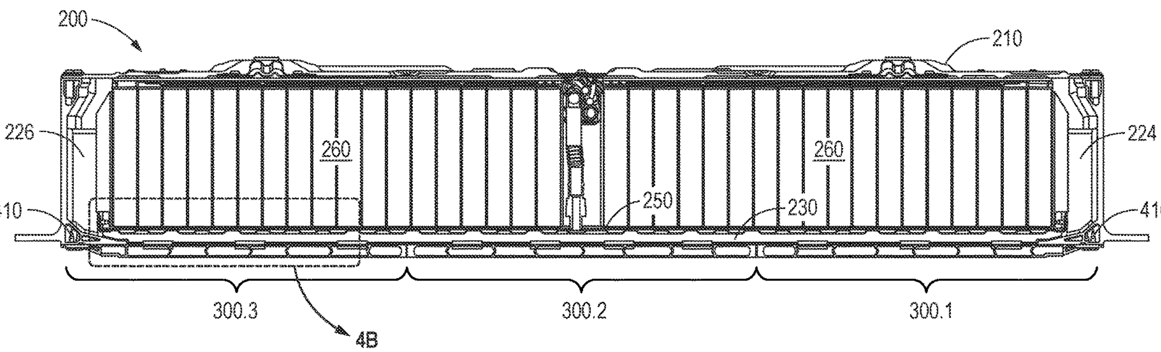

200
210
226
260
260
224
410
250
230
410
300.3
300.2
300.1
4B

FIG. 4A

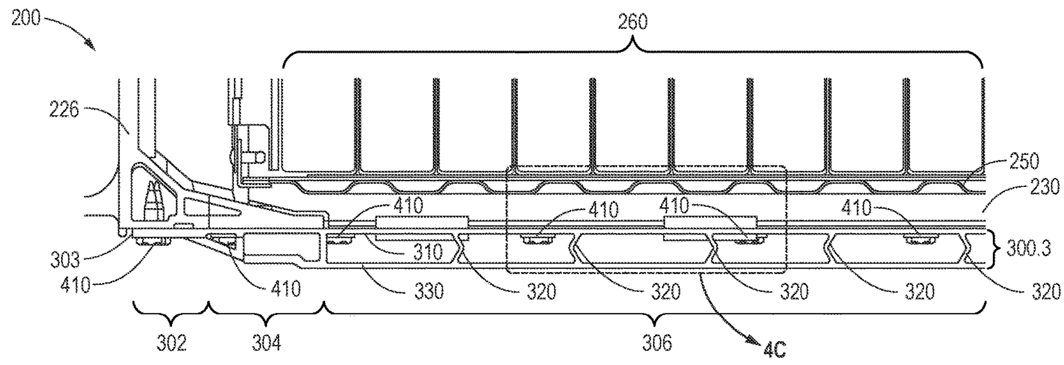

200
260
226
250
230
410
410
410
410
303
410
310
300.3
410
330
320
320
320
320
320
302
304
306
4C

FIG. 4B

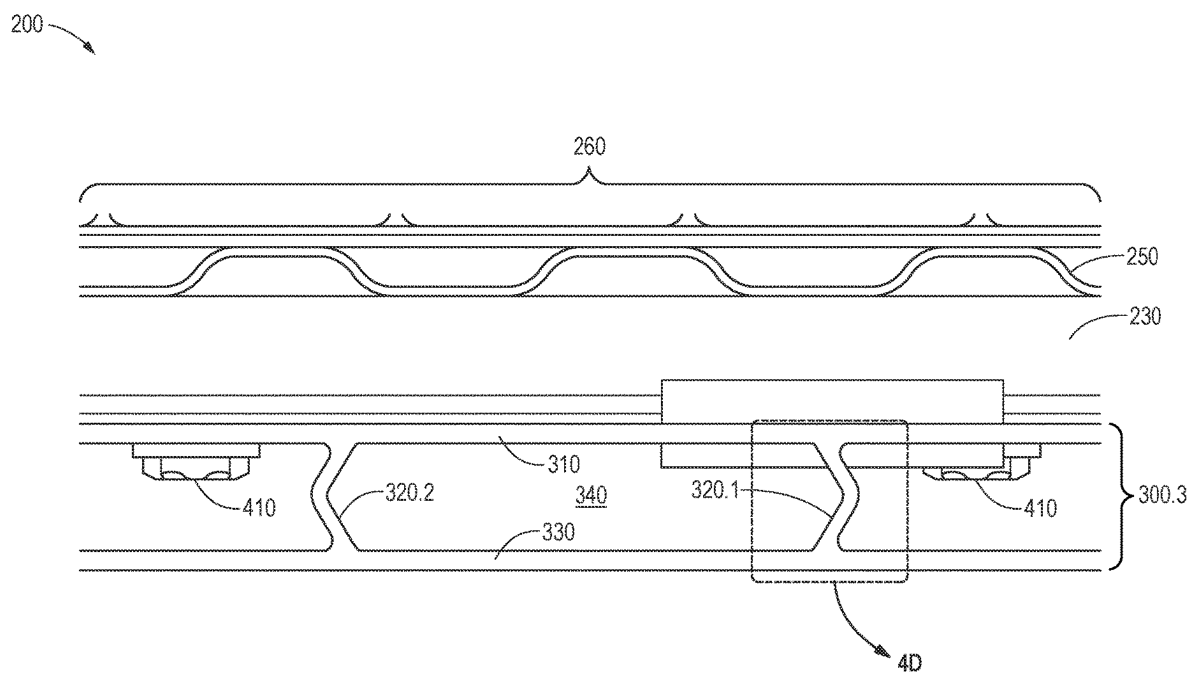


FIG. 4C

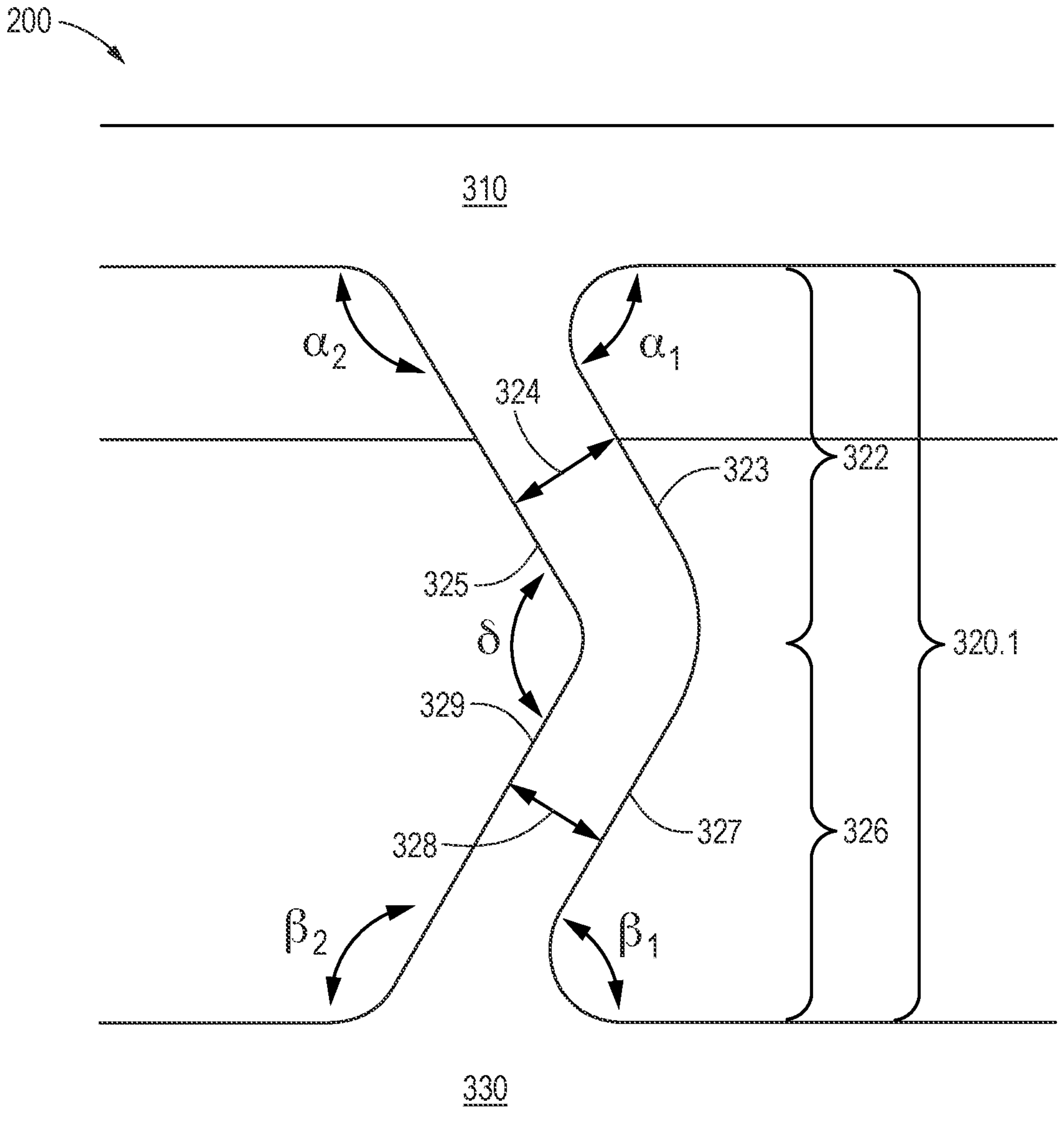

200
310
α_2
α_1
324
322
323
325
δ
320.1
329
328
327
326
β_2
β_1
330

FIG. 4D

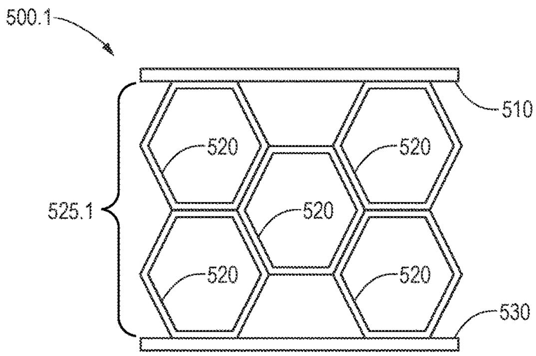


FIG. 5A

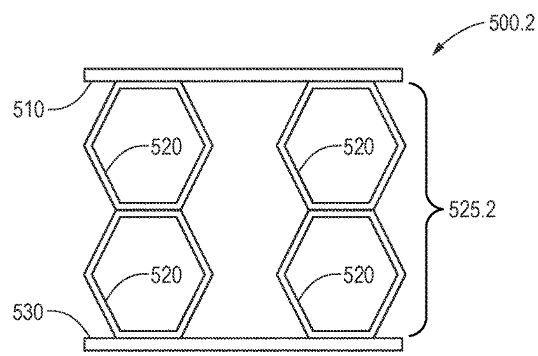


FIG. 5B

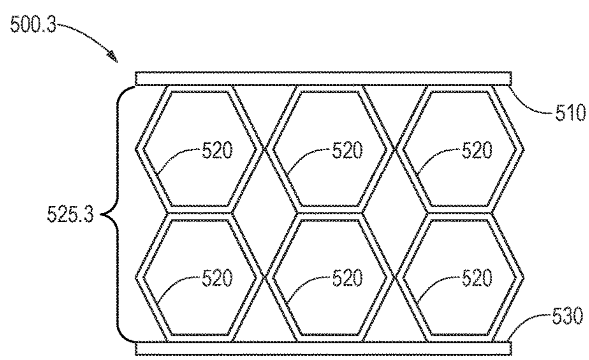


FIG. 5C

ENERGY ABSORBING COMPONENT FOR BATTERY ENCLOSURE

INTRODUCTION

[0001] The present disclosure relates to electric vehicles (EVs). More particularly, the present disclosure relates to battery enclosures for electric vehicles.

SUMMARY

[0002] Embodiments of the present disclosure advantageously provide an apparatus, such as an energy absorbing component for a battery enclosure, that includes a collapsible structure disposed between an upper member and a lower member.

[0003] In certain embodiments, the energy absorbing component includes collapsible ribs disposed between a first member and a second member of a battery enclosure. The collapsible ribs are configured to deform to absorb impact energy. Each collapsible rib includes a first portion joined to the first member, and a second portion joined to the second member. The first portion has a first thickness, and the second portion has a second thickness that is different than the first thickness.

[0004] In other certain embodiments, an array of collapsible polygonal tubes is disposed between a first member and a second member of a battery enclosure. The array of collapsible polygonal tubes is configured to deform to absorb impact energy. The array of collapsible polygonal tubes is integrally formed with at least one of the first member and the second member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** depicts a diagram of an example electric vehicle, in accordance with embodiments of the present disclosure.

[0006] FIG. **2** depicts a front perspective view of an example battery enclosure for an electric vehicle, in accordance with embodiments of the present disclosure.

[0007] FIG. **3** depicts a bottom view of an example battery enclosure with an example energy absorbing component, in accordance with embodiments of the present disclosure.

[0008] FIG. **4**A depicts a transverse sectional view of an example battery enclosure with an example energy absorbing component, in accordance with embodiments of the present disclosure.

[0009] FIG. **4**B depicts a portion of the transverse sectional view depicted in FIG. **4**A, in accordance with embodiments of the present disclosure.

[0010] FIG. **4**C depicts a portion of the transverse sectional view depicted in FIG. **4**B, in accordance with embodiments of the present disclosure.

[0011] FIG. **4**D depicts a portion of the transverse sectional view depicted in FIG. **4**C, in accordance with embodiments of the present disclosure.

[0012] FIGS. **5**A, **5**B, **5**C depict transverse sectional views of example energy absorbing components, in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0013] A battery enclosure for an electric vehicle provides a sealed housing to protect the battery pack from exposure to water, dust, debris and other elements. In one example, the battery enclosure may include, inter alia, a battery pack, a bottom tray that supports the battery pack, a frame attached to the bottom tray, and a top cover (or tub) attached to the frame (and/or the bottom tray). In another example, the battery enclosure may include a battery pack, a bottom tub that supports the battery pack, a frame attached to the bottom tub, and a top cover (or tray) attached to the frame (and/or the bottom tub).

[0014] The top cover may be sealed to the bottom tray (or tub), and the frame may include one or more longitudinal members that are located within the enclosed space formed by the top cover and the bottom tray or tub. Alternatively, the frame may include transverse and longitudinal members that form a rectangular outer frame, the top cover may be sealed to the upper surface of the frame, and the bottom tray or tub may be sealed to the lower surface of the frame. Additionally, one or more cooling plates may be attached to, or integrally formed with, the bottom tray (or tub) and/or the top cover. Alternatively, one or more cooling plates may be attached to the sides of the battery pack, located within the battery pack, etc.

[0015] Other configurations of the battery enclosure are also possible.

[0016] A battery enclosure for an electric vehicle has strict structural and sealing requirements. The structural requirements may include, inter alia, a satisfactory reaction to an impact load, such as an underside impact (i.e., an impact to the underside of the vehicle), a side pole impact, a frontal offset impact, etc. The sealing requirements may include, inter alia, protection against water ingress, remaining sealed through 5 minutes of thermal runaway, etc.

[0017] Battery enclosures typically implement lightweight, metallic panels or sheets for many components, including the bottom tray (or tub) and the top cover of the battery enclosure. However, such panels can be damaged by various types of impact loads. For example, an impact load caused by road debris (such as rocks, pieces of asphalt, pieces of metal, tree branches, etc.) may damage a bottom portion of the metallic panel underneath the battery pack. Additionally, the road debris may penetrate through the metallic panel possibly leading to further damage.

[0018] Embodiments of the present disclosure advantageously provide an energy absorbing component for a battery enclosure that includes a collapsible structure disposed between a first member and a second member. The collapsible structure is configured to absorb impact energy. In some embodiments, the collapsible structure can be integrally formed with the first member and/or the second member (such as by an aluminum extrusion process, etc.).

[0019] In certain embodiments, the collapsible structure may include collapsible ribs. Each collapsible rib includes at least a first portion joined to the first member, and a second portion joined to the second member. The first portion of each collapsible rib has a different thickness than the second portion of each collapsible rib (such as 1.8 mm vs. 1.6 mm, etc.). A first surface of the first portion forms an acute angle with respect to the first member, such as 30°, 45°, 60°, 75°, etc. A second surface of the first portion (opposite to the first surface) forms an obtuse angle with respect to the first member, such as 120°, 135°, 150°, 165°, etc. Similarly, a first surface of the second portion forms an acute angle with respect to the second member, such as 30°, 45°, 60°, 75°, etc. A second surface of the second portion (opposite to the first surface) forms an obtuse angle with respect to the second member, such as 120°, 135°, 150°, 165°, etc.

[0020] Advantageously, due to the variable thickness and angular cross-section of the collapsible ribs, at least a portion of the collapsible ribs will deform to absorb at least a portion of the impact energy. Absorbing at least a portion of the impact energy may prevent a breach of the sealed battery enclosure, and may prevent or reduce damage to the cold plate and battery pack.

[0021] In certain other embodiments, the energy absorbing collapsible structure may include an array of collapsible polygonal tubes (such as hexagonal tubes, etc.) that may be integrally formed with the first member and/or the second member. Advantageously, due to the angular cross-section of the polygonal tubes, at least a portion of the array of collapsible polygonal tubes will deform to absorb at least a portion of the impact energy.

[0022] FIG. **1** depicts a diagram of electric vehicle **100**, in accordance with embodiments of the present disclosure.

[0023] Electric vehicle **100** includes, inter alia, a frame and body **110**, an electrical power storage and distribution system, a propulsion system, a suspension system, a steering system, auxiliary and accessory systems (such as thermal management, lighting, wireless communications, navigation, etc.), etc.

[0024] Generally, body **110** may be directly or indirectly mounted to a frame (i.e., body-on-frame construction), or body **110** may be formed integrally with a frame (i.e., unibody construction). Body **110** includes, inter alia, front end **120**, front light bar **122**, front turn lights **123**, stadium light ring **124**, headlights **126**, charging port **130** with charging port cover **136** concealing charging connector socket, driver/passenger compartment or cabin **140**, bed **150**, rear end **160** with rear tail lights **162**, a rear light bar, etc. Electric vehicle **100** may be a pickup truck, a sport utility vehicle (SUV) in which bed **150** is replaced by an extension of cabin **140**, or a sedan in which bed **150** is replaced by a trunk. In certain embodiments, electric vehicle may be an electric delivery vehicle, an electric cargo van, etc.

[0025] The propulsion system may include, inter alia, one or more ECUs, one or more EDUs, wheels **170**, etc. The electrical power storage and distribution system may include, inter alia, one or more ECUs, a battery pack including one or more battery modules, a vehicle charging subsystem including charging port **130**, high voltage (HV) cables, etc.

[0026] FIG. **2** depicts a front perspective view of battery enclosure **200** for an electric vehicle, in accordance with embodiments of the present disclosure.

[0027] Battery enclosure **200** includes, inter alia, top cover **210**, frame **220**, bottom tub **230**, power electronics enclosure **240**, and a battery pack (not shown in FIG. **2**). Frame **220** includes front member **222**, side member **224**, side member **226**, and rear member **228** that form a rectangular outer frame. Top cover **210** is a tray that is sealed to the upper surfaces of front member **222**, side member **224**, side member **226**, and rear member **228**. Bottom tub **230** is sealed to the lower surfaces of front member **222**, side member **224**, side member **226**, and rear member **228**. Power electronics enclosure **240** is attached to front member **222**, and contains high voltage power distribution components for the battery pack.

[0028] FIG. **3** depicts a bottom view of battery enclosure **200** with energy absorbing component **300**, in accordance with embodiments of the present disclosure.

[0029] Generally, energy absorbing component **300** is attached to front member **222**, rear member **228**, side member **224**, side member **226**, and bottom tub **230** using fasteners, such as screws, bolts, rivets, etc. Because energy absorbing component **300** covers the entirety of the lower surface of bottom tub **230**, energy absorbing component **300** protects battery enclosure **200** from underside impacts caused by road debris (such as rocks, stones, pieces of asphalt, pieces of metal, tree branches, etc.). In other embodiments, energy absorbing component **300** may cover a portion of the lower surface of bottom tub **230**, such as 90%, 80%, etc.

[0030] In certain embodiments, energy absorbing component **300** may include a number of smaller energy absorbing components **300**.*i*, such as energy absorbing components **300.1**, **300.2**, **300.3**. Energy absorbing component **300.1** is attached to a portion of front member **222**, side member **224**, a portion of rear member **228**, and a portion of bottom tub **230**. Energy absorbing component **300.2** is attached to a portion of front member **222**, a portion of rear member **228**, and a portion of bottom tub **230**. Energy absorbing component **300.3** is attached to a portion of front member **222**, side member **226**, a portion of rear member **228**, and a portion of bottom tub **230**. In other embodiments, two energy absorbing components **300**.*i* may be used to cover the lower surface of bottom tub **230**, four energy absorbing components **300**.*i* may be used to cover the lower surface of bottom tub **230**, etc.

[0031] When additional protection is desired (such as from side impacts, etc.), energy absorbing components **300** may be attached to front member **222**, side member **224**, side member **226**, and/or rear member **228**. These energy absorbing components **300** may cover the entirety of the frame members, a portion of the frame members, etc. One or more energy absorbing components **300** may also protect top cover **210**, if desired.

[0032] FIG. **4**A depicts a transverse sectional view of battery enclosure **200** with energy absorbing components **300.1**, **300.2**, **300.3**, in accordance with embodiments of the present disclosure.

[0033] Top cover **210**, side member **224**, side member **226**, bottom tub **230**, cooling plate **250**, battery pack **260**, and energy absorbing components **300.1**, **300.2**, **300.3** are depicted.

[0034] Cooling plate **250** includes multiple flow channels that are coupled to a cooling manifold that circulates cooling fluid through cooling plate **250**. Battery pack **260** includes multiple battery cells, such as prismatic cells, cylindrical cells, pouch cells, etc.; in certain embodiments, battery pack **260** may be organized into a number of battery modules.

[0035] As depicted in FIG. **4**A, energy absorbing component **300.1** is attached to side member **224** using fastener **410**, and energy absorbing component **300.3** is attached to side member **226** using fastener **410**. Fasteners are also used to attach energy absorbing components **300.1**, **300.2**, **300.3** to bottom tub **230** (as depicted in FIGS. **4**B, **4**C for energy absorbing component **300.3**).

[0036] FIG. **4**B depicts a portion of the transverse sectional view depicted in FIG. **4**A, in accordance with embodiments of the present disclosure.

[0037] Side member **226**, bottom tub **230**, cooling plate **250**, battery pack **260**, energy absorbing component **300.3**, and fasteners **410** are depicted.

[0038] Generally, energy absorbing component **300.3** includes outer section **302**, transition section **304**, and collapsible section **306**. Similarly, energy absorbing component **300.1** includes an outer section that is attached to side member **224**, a transition section, and a collapsible section. Energy absorbing component **300.2** includes a collapsible section that is attached to the collapsible sections of energy absorbing components **300.1**, **300.3**.

[0039] Outer section **302** includes flange **303** that receives fasteners **410** to attach energy absorbing component **300.3** to side member **226** (as well as front member **222** and rear member **228**). Transition section **304** joins relatively flat outer section **302** to collapsible section **306**, and also receives fasteners **410** to attach energy absorbing component **300.3** to bottom tub **230**. Collapsible section **306** receives fasteners **410** to attach energy absorbing component **300.3** to bottom tub **230**.

[0040] Collapsible section **306** includes first member **310**, collapsible ribs **320**, and second member **330**. First member **310** may be a generally flat surface that receives fasteners **410** to attach energy absorbing component **300.3** to bottom tub **230** of battery enclosure **200**. Collapsible ribs **320** are disposed between first member **310** and second member **330**, and are configured to deform to absorb impact energy (as discussed below).

[0041] In the configuration depicted in FIGS. **4**A to **4**D, first member **310** is an upper plate (e.g., positioned between the battery pack **260** and the second member **330**), and second member **330** is a lower plate (e.g., positioned between the first member **310** and an environment external to the battery enclosure **200**, such as between the first member **310** and a surface on which the vehicle is driving). When energy absorbing component **300.3** is attached to top cover **210**, energy absorbing component **300.3** is rotated 180° so that first member **310** is a lower plate, and second member **330** is an upper plate. When energy absorbing component **300.3** is attached to front member **222**, side member **224**, side member **226**, and/or rear member **228**, energy absorbing component **300.3** is rotated 90° so that first member **310** is an inner plate, and second member **330** is an outer plate.

[0042] In certain embodiments, collapsible ribs **320** may be integrally formed with first member **310** and/or second member **330**, such as by an aluminum extrusion process. For example, the first member, second member and collapsible ribs may be extruded in various ways. In one example, the collapsible ribs and the first member may be extruded as a single piece and then attached to the second member. In another example, the collapsible ribs and the second member may be extruded as a single piece and then attaches to the first member. In a further example, the collapsible ribs, the first member, and the second member may be extruded as a single piece. The extruded pieces may be attached together by welding, brazing, soldering, adhesive, etc.

[0043] FIG. **4**C depicts a portion of the transverse sectional view depicted in FIG. **4**B, in accordance with embodiments of the present disclosure.

[0044] Bottom tub **230**, cooling plate **250**, battery pack **260**, energy absorbing component **300.3**, and fasteners **410** are depicted.

[0045] In certain embodiments, collapsible ribs **320** may include collapsible ribs **320.1** and collapsible ribs **320.2**. Collapsible ribs **320.1** have an angular cross-section with a first orientation (such as a chevron shape pointing in a first direction), while collapsible ribs **320.2** have an angular cross-section with a second orientation that is opposite to the first orientation (such as a chevron shape pointing in a second direction).

[0046] As depicted in FIGS. **4**A, **4**B, **4**C, each pair of adjacent collapsible ribs **320** have different orientations. In other words, each pair of adjacent collapsible ribs **320** includes one collapsible rib **320.1** and one collapsible rib **320.2**. In certain other embodiments, collapsible ribs **320** may include collapsible ribs **320.1** (only), and each pair of adjacent collapsible ribs **320.1** have the same orientation. Similarly, collapsible ribs **320** may include collapsible ribs **320.2** (only), and each pair of adjacent collapsible ribs **320.2** have the same orientation.

[0047] For example, each adjacent pair of collapsible ribs may include a first collapsible rib and a second collapsible rib. The first collapsible rib has a chevron shape pointing in the first direction (such as to the right) and the second collapsible rib has a chevron shape pointing in the first direction. Or, the first collapsible rib has a chevron shape pointing in the first direction and the second collapsible rib has a chevron shape pointing in the second direction (such as to the left). Or, the first collapsible rib has a chevron shape pointing in the second direction and the second collapsible rib has a chevron shape pointing in the first direction. Or, the first collapsible rib has a chevron shape pointing in the second direction and the second collapsible rib has a chevron shape pointing in the second direction.

[0048] Other combinations of collapsible ribs **320.1**, **320.2** are also contemplated, such as a repeating sequence of collapsible ribs **320.1**, **320.2** that includes more than two pairs of collapsible ribs **320** in the sequence.

[0049] Generally, each pair of adjacent collapsible ribs **320**, a portion of first member **310**, and a portion of second member **330** define channel **340**. In certain embodiments, metal foam or crushable plastic may be disposed in each channel **340**.

[0050] FIG. **4**D depicts a portion of the transverse sectional view depicted in FIG. **4**C, in accordance with embodiments of the present disclosure.

[0051] First member **310**, collapsible rib **320.1**, and second member **330** are depicted. The following discussion also applies to collapsible rib **320.2**, which is a mirror image of collapsible rib **320.1**. Generally, collapsible rib **320.1** has a chevron shape that is pointed in the first direction (such as to the right, which is also known as a right chevron or a right-pointing chevron). Collapsible rib **320.2** has a chevron shape that is pointed in the second direction (such as to the left, which is also known as a left chevron or a left-pointing chevron).

[0052] Collapsible rib **320.1** includes first portion **322** joined to first member **310**, and second portion **326** joined to second member **330**. In certain embodiments, first portion **322** and second portion **326** merge at the center of collapsible rib **320.1**, while in other embodiments, first portion **322** and second portion **326** may merge above or below the center of collapsible rib **320.1**.

[0053] First portion **322** includes first surface **323**, center thickness **324**, and second surface **325**. First surface **323** forms angle **1** with respect to first member **310** that is less than 90°. In certain embodiments, angle α_1 may be between 45° and 75°, such as 60°. Similarly, second surface **325** forms angle α_2 with respect to first member **310** that is greater than 90°. In certain embodiments, angle α_2 may be between 135° and 165°, such as 150°. In some embodiments, angle α_1 and angle α_1 may be supplementary angles.

[0054] Second portion **326** includes first surface **327**, center thickness **328**, and second surface **329**. First surface **327** forms angle β_1 with respect to second member **330** that is less than 90°. In certain embodiments, angle β_1 may be between 45° and 75°, such as 60°. Similarly, second surface **329** forms angle β_2 with respect to second member **330** that is greater than 90°. In certain embodiments, angle β_2 may be between 135° and 165°, such as 150°. In some embodiments, angle β_1 and angle β_1 may be supplementary angles.

[0055] Second surface **325** and second surface **329** form angle δ with respect to one another.

[0056] Center thickness **324** and center thickness **328** may be different. In certain embodiments, center thickness **328** is less than center thickness **324**, while in other embodiments, center thickness **328** is greater than center thickness **324**. The difference in thickness may be about 10%, such as 1.6 mm and 1.8 mm, 1.5 mm and 2.0 mm. Other thickness differences are also supported, such as 5% 15%, 20%, 25%, 30%, 50%, etc.

[0057] Advantageously, collapsible rib **320.1** will deform to absorb a portion of the impact energy from an impact load due to the angles α_1, α_2, β_1, β_2, and δ of collapsible rib **320.1** and the difference in center thickness **324** and center thickness **329**.

[0058] In certain other embodiments, center thickness **328** may be the same as center thickness **324**, and collapsible rib **320.1** will deform to absorb a portion of the impact energy from an impact load due to the angles α_1, α_2, β_1, β_2, and δ of collapsible rib **320.1**.

[0059] FIGS. **5**A, **5**B, **5**C depict a transverse sectional view of energy absorbing components **500.1**, **500.2**, **500.3**, respectively, in accordance with embodiments of the present disclosure.

[0060] In certain embodiments, energy absorbing component **500.1** includes first member **510**, array **525.1** of collapsible polygonal tubes **520**, and second member **530**. Generally, first member **510** is the same (and performs the same functions) as first member **310**, and second member **530** is the same (and performs the same functions) as second member **330**. Array **525.1** is configured to deform to absorb impact energy, and may be integrally formed with first member **510** and/or second member **530**, such as by the aluminum extrusion process described above. In certain embodiments, at least a portion of array **525.1** of collapsible polygonal tubes **520** deforms to absorb at least a portion of the impact energy.

[0061] In certain embodiments, energy absorbing component **500.2** includes first member **510**, array **525.2** of collapsible polygonal tubes **520**, and second member **530**. Generally, first member **510** is the same (and performs the same functions) as first member **310**, and second member **530** is the same (and performs the same functions) as second member **330**. Array **525.2** is configured to deform to absorb impact energy, and may be integrally formed with first member **510** and/or second member **530**, such as by the aluminum extrusion process described above. In certain embodiments, at least a portion of array **525.2** of collapsible polygonal tubes **520** deforms to absorb at least a portion of the impact energy.

[0062] In certain embodiments, energy absorbing component **500.3** includes first member **510**, array **525.3** of collapsible polygonal tubes **520**, and second member **530**. Generally, first member **510** is the same (and performs the same functions) as first member **310**, and second member **530** is the same (and performs the same functions) as second member **330**. Array **525.3** is configured to deform to absorb impact energy, and may be integrally formed with first member **510** and/or second member **530**, such as by the aluminum extrusion process described above. In certain embodiments, at least a portion of array **525.3** of collapsible polygonal tubes **520** deforms to absorb at least a portion of the impact energy.

[0063] In certain embodiments, each collapsible polygonal tube **520** has a hexagonal cross-sectional shape. In other embodiments, each collapsible polygonal tube **520** may have a pentagonal cross-sectional shape, a heptagonal cross-sectional shape, etc.

[0064] In certain embodiments, metal foam or crushable plastic may be disposed in each polygonal tube **520**.

[0065] The many features and advantages of the disclosure are apparent from the detailed specification, and, thus, it is intended by the appended claims to cover all such features and advantages of the disclosure which fall within the scope of the disclosure. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the disclosure to the exact construction and operation illustrated and described, and, accordingly, all suitable modifications and equivalents may be resorted to that fall within the scope of the disclosure.

What is claimed is:

1. An energy absorbing component, comprising:

collapsible ribs disposed between a first member and a second member of a battery enclosure, the collapsible ribs configured to deform to absorb impact energy,

wherein each collapsible rib comprises:

a first portion joined to the first member, the first portion having a first thickness, and

a second portion joined to the second member, the second portion having a second thickness that is different than the first thickness.

2. The energy absorbing component of claim **1**, wherein the second thickness is about 5% to about 50% less than the first thickness.

3. The energy absorbing component of claim **1**, wherein:

the first portion has a first surface that forms a first angle with respect to the first member that is between 45° and 75°;

the first portion has a second surface that forms a second angle with respect to the first member that is between 135° and 165°;

the second portion has a first surface that forms a third angle with respect to the second member that is between 45° and 75°; and

the second portion has a second surface that forms a fourth angle with respect to the second member that is between 135° and 165°.

4. The energy absorbing component of claim **3**, wherein:

the third angle is the same as the first angle; and

the fourth angle is the same as the second angle.

5. The energy absorbing component of claim **1**, wherein each collapsible rib has a chevron shape pointing in a first direction or a second direction opposite to the first direction.

6. The energy absorbing component of claim **5**, wherein each adjacent pair of collapsible ribs includes a first collapsible rib and a second collapsible rib, and wherein:

the first collapsible rib has a chevron shape pointing in the first direction and the second collapsible rib has a chevron shape pointing in the first direction;

the first collapsible rib has a chevron shape pointing in the first direction and the second collapsible rib has a chevron shape pointing in the second direction;

the first collapsible rib has a chevron shape pointing in the second direction and the second collapsible rib has a chevron shape pointing in the first direction; or

the first collapsible rib has a chevron shape pointing in the second direction and the second collapsible rib has a chevron shape pointing in the second direction.

7. The energy absorbing component of claim **1**, wherein the first portion of each collapsible rib and the second portion of each collapsible rib meet at a center of each collapsible rib to define an angular cross-section of each collapsible rib.

8. The energy absorbing component of claim **7**, wherein:

the angular cross-section of each collapsible rib has a first orientation or a second orientation that is opposite to the first orientation; and

the angular cross-sections of each pair of adjacent collapsible ribs have different orientations, or the angular cross-sections of each pair of adjacent collapsible ribs have a same orientation.

9. The energy absorbing component of claim **1**, wherein each pair of adjacent collapsible ribs, a portion of the first member, and a portion of the second member define a channel.

10. The energy absorbing component of claim **9**, wherein metal foam or crushable plastic is disposed in each channel.

11. The energy absorbing component of claim **1**, wherein:

the first member is an upper plate and the second member is a lower plate;

the first member is the lower plate and the second member is the upper plate; or

the first member is an inner plate and the second member is an outer plate.

12. The energy absorbing component of claim **1**, wherein:

the first member, the second member, and the collapsible ribs are formed by extrusion; and

the collapsible ribs are extruded with the first member and attached to the second member, the collapsible ribs are extruded with the second member and attached to the first member, or the first member, the second member, and the collapsible ribs are extruded together.

13. An energy absorbing component, comprising:

an array of collapsible polygonal tubes disposed between a first member and a second member of a battery enclosure, the array of collapsible polygonal tubes configured to deform to absorb impact energy,

wherein the array of collapsible polygonal tubes is integrally formed with at least one of the first member and the second member.

14. The energy absorbing component of claim **13**, wherein each collapsible polygonal tube has a hexagonal cross-sectional shape.

15. The energy absorbing component of claim **13**, wherein at least a portion of the array of collapsible polygonal tubes deforms to absorb at least a portion of the impact energy.

16. The energy absorbing component of claim **13**, wherein:

the first member is an upper plate and the second member is a lower plate;

the first member is the lower plate and the second member is the upper plate; or

the first member is an inner plate and the second member is an outer plate.

17. The energy absorbing component of claim **13**, wherein:

the first member is formed by extrusion;

the second member is formed by extrusion;

the collapsible polygonal tubes are formed by extrusion; and

the collapsible polygonal tubes are extruded with the first member and attached to the second member, the collapsible polygonal tubes are extruded with the second member and attached to the first member, or the first member, the second member and the collapsible polygonal tubes are extruded together.

18. The energy absorbing component of claim **13**, wherein metal foam or crushable plastic is disposed in each collapsible polygonal tube.

19. A method, comprising:

providing an energy absorbing component for a battery pack, the energy absorbing component including:

collapsible ribs disposed between a first member and a second member of a battery enclosure, the collapsible ribs configured to deform to absorb impact energy, wherein each collapsible rib comprises:

a first portion joined to the first member, the first portion having a first thickness, and

a second portion joined to the second member, the second portion having a second thickness that is different than the first thickness.

20. The method of claim **19**, wherein:

the second thickness is about 5% to about 50% less than the first thickness;

the first portion of each collapsible rib and the second portion of each collapsible rib meet at a center of each collapsible rib to define an angular cross-section of each collapsible rib; and

each pair of adjacent collapsible ribs, a portion of the first member, and a portion of the second member define a channel.

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