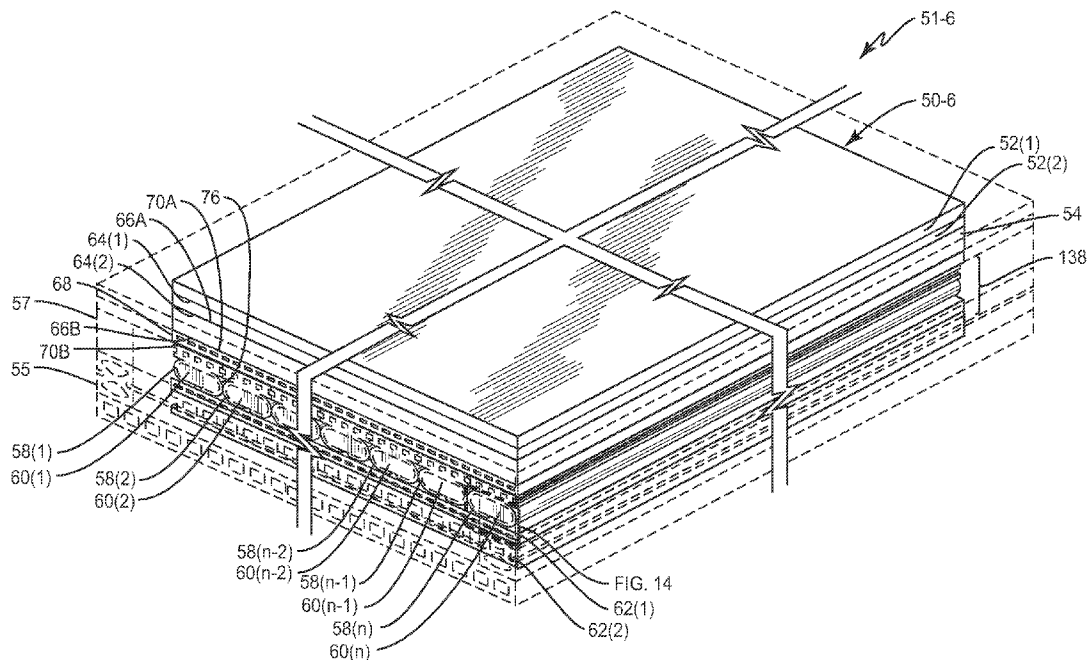




US 20140130265A1

(19) **United States**(12) **Patent Application Publication**
Lauer et al.(10) **Pub. No.: US 2014/0130265 A1**(43) **Pub. Date: May 15, 2014**(54) **ALL-FOAM MATTRESS ASSEMBLIES WITH
FOAM ENGINEERED CORES HAVING
THERMOPLASTIC AND THERMOSET
MATERIALS, AND RELATED ASSEMBLIES
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(US)(21) Appl. No.: **14/066,966**(22) Filed: **Oct. 30, 2013****Related U.S. Application Data**(60) Provisional application No. 61/724,556, filed on Nov.
9, 2012.**Publication Classification**(51) **Int. Cl.**
A47C 27/14 (2006.01)
A47C 27/20 (2006.01)
(52) **U.S. Cl.**
CPC *A47C 27/148* (2013.01); *A47C 27/20*
(2013.01)
USPC **5/716; 5/727**(57) **ABSTRACT**

All-foam mattress assemblies with foam engineered cores having thermoplastic and thermoset materials, and related assemblies and methods are disclosed. All-foam mattress assemblies use foam-based materials, such as thermoplastic and thermoset, to provide cushioning and support characteristics for a user in the sleeping area of a mattress during sleep or rest. The all-foam mattress assemblies may include foam comfort layer(s), foam transitional layer(s), and a foam engineered core. The all-foam engineered core may lessen a density of a mattress assembly by comprising thermoset member(s), and engineered geometric thermoplastic material profile(s) adjacent to the thermoset member(s). The engineered geometric thermoplastic material profile(s) may be disposed in a parallel or substantially parallel arrangement. In this manner, the all-foam engineering core may provide cushioning and support characteristics with reduced density compared to a foam mattress providing similar cushioning and support through solid thermoset layers.



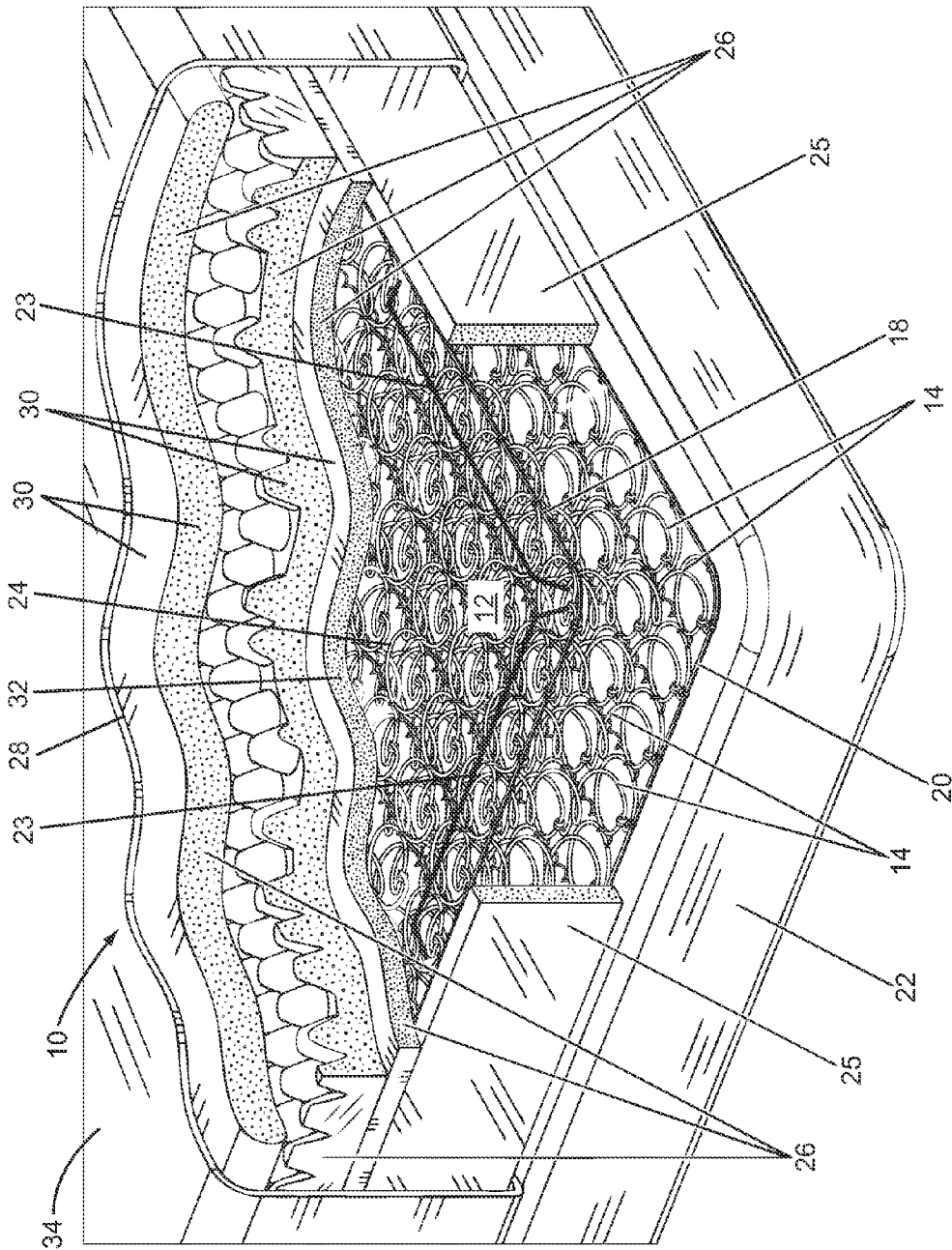


FIG. 1A
PRIOR ART

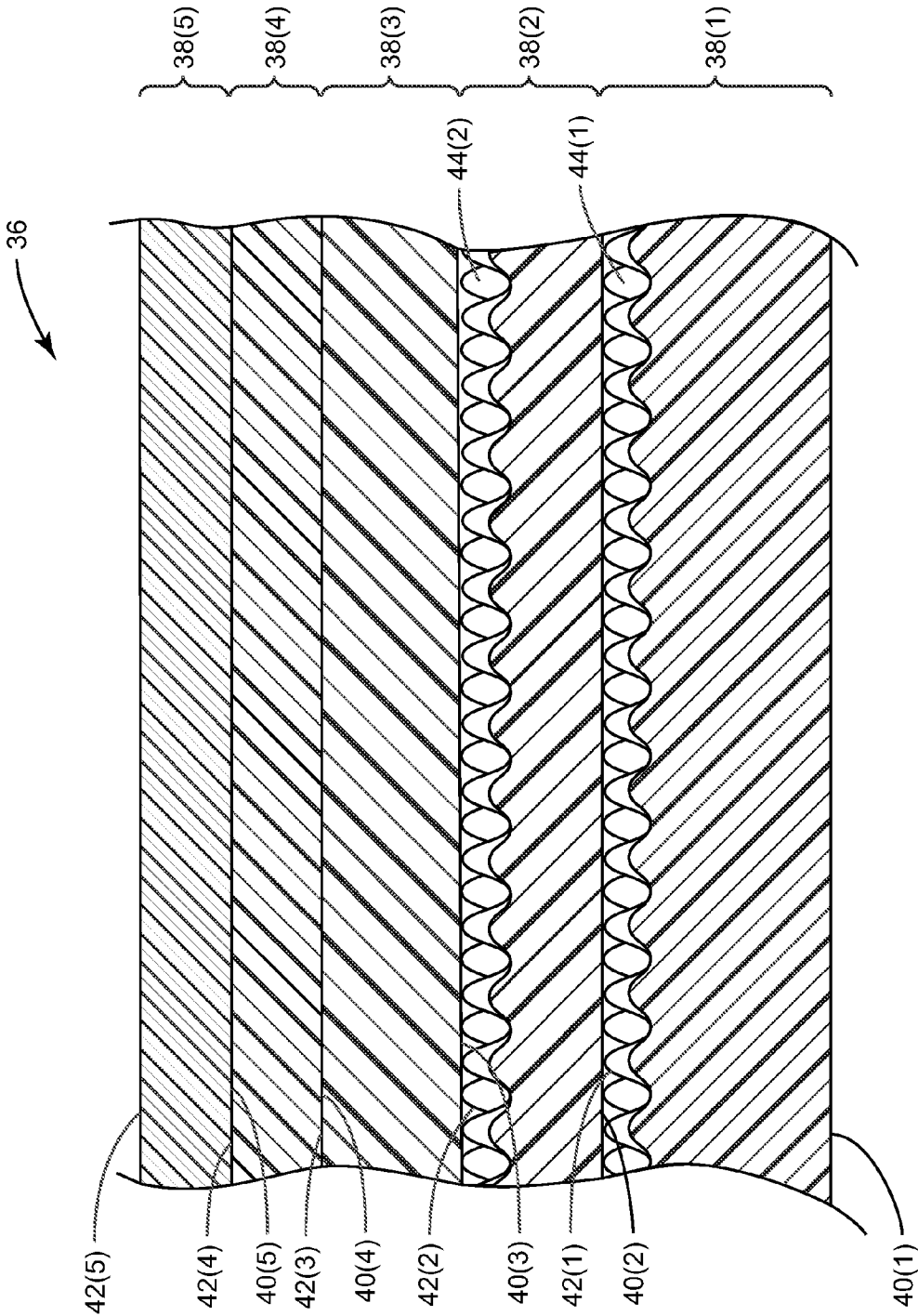


FIG. 1B
PRIOR ART

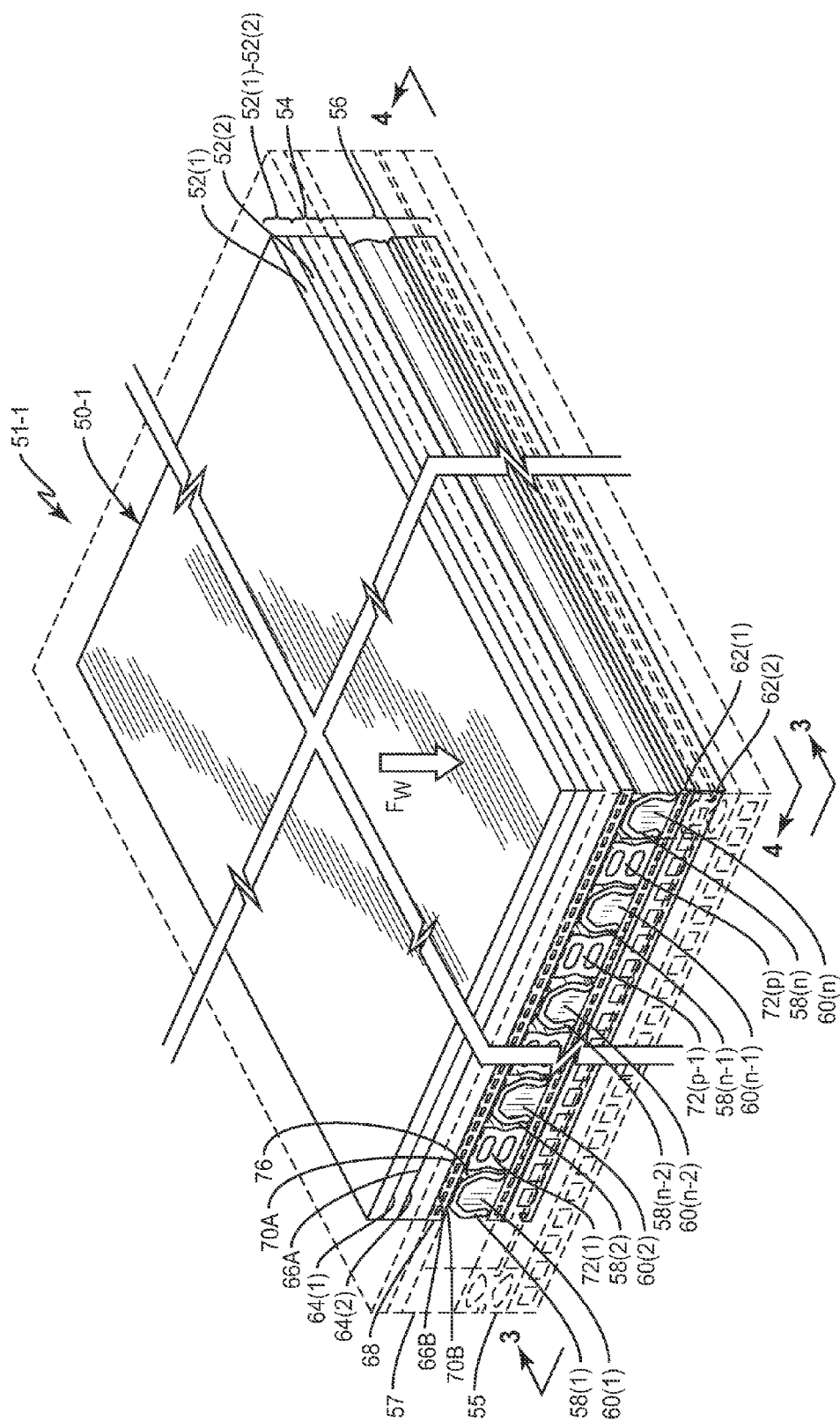
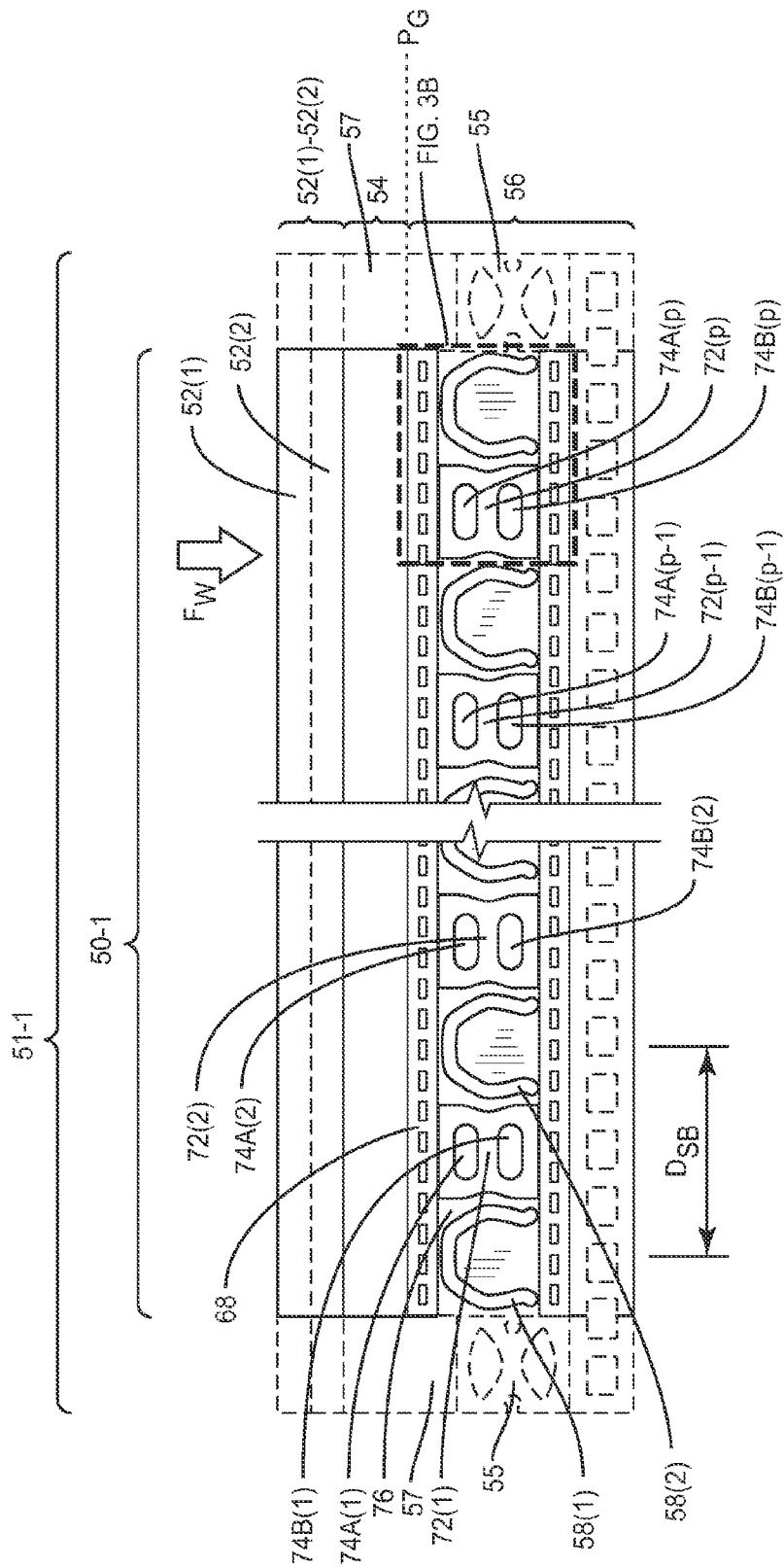


FIG. 2



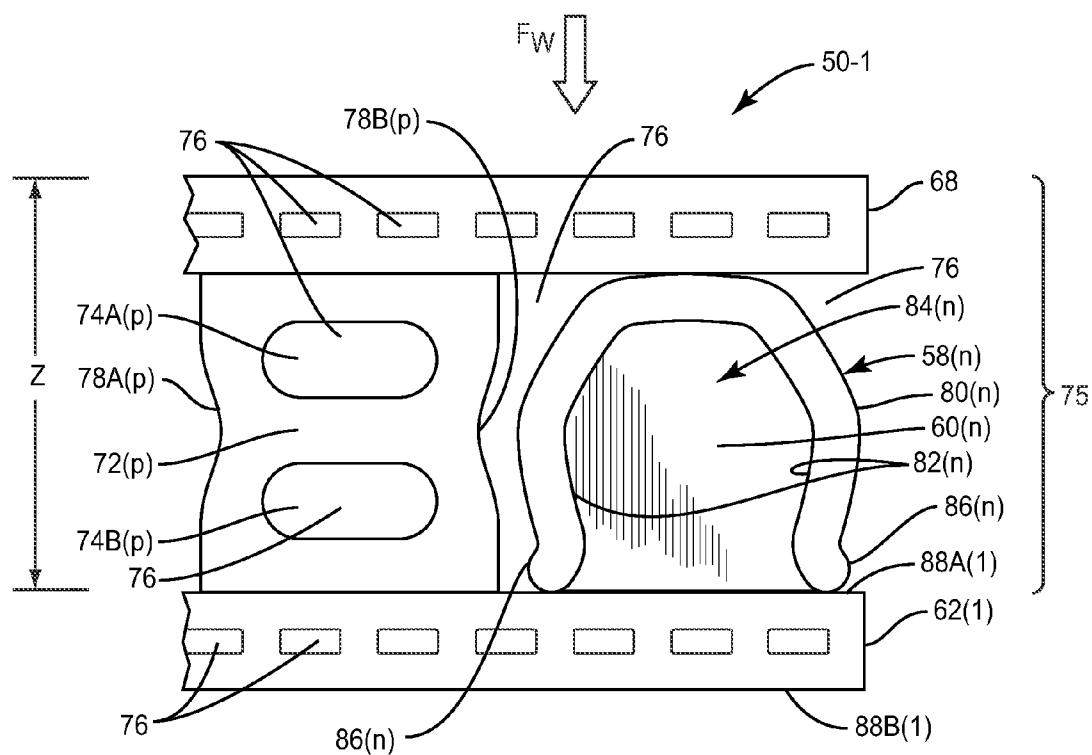


FIG. 3B

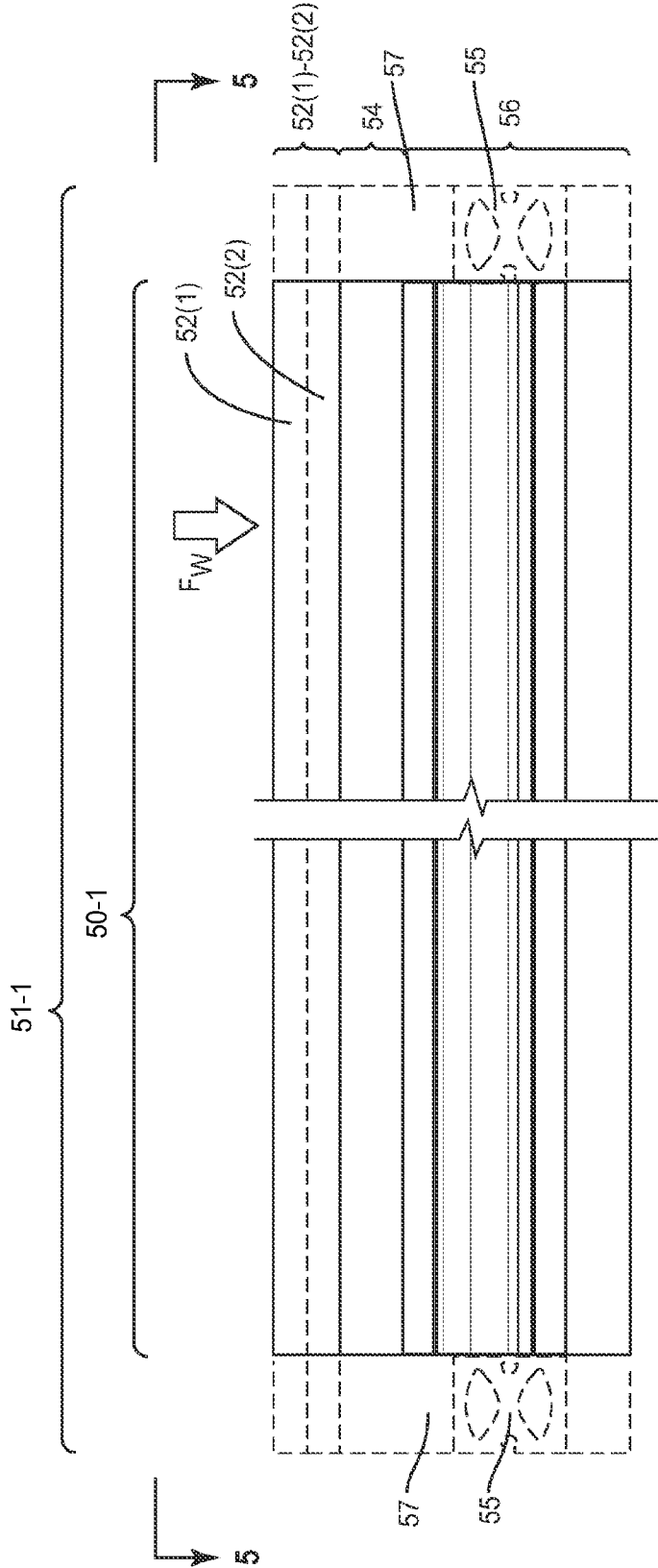


FIG. 4

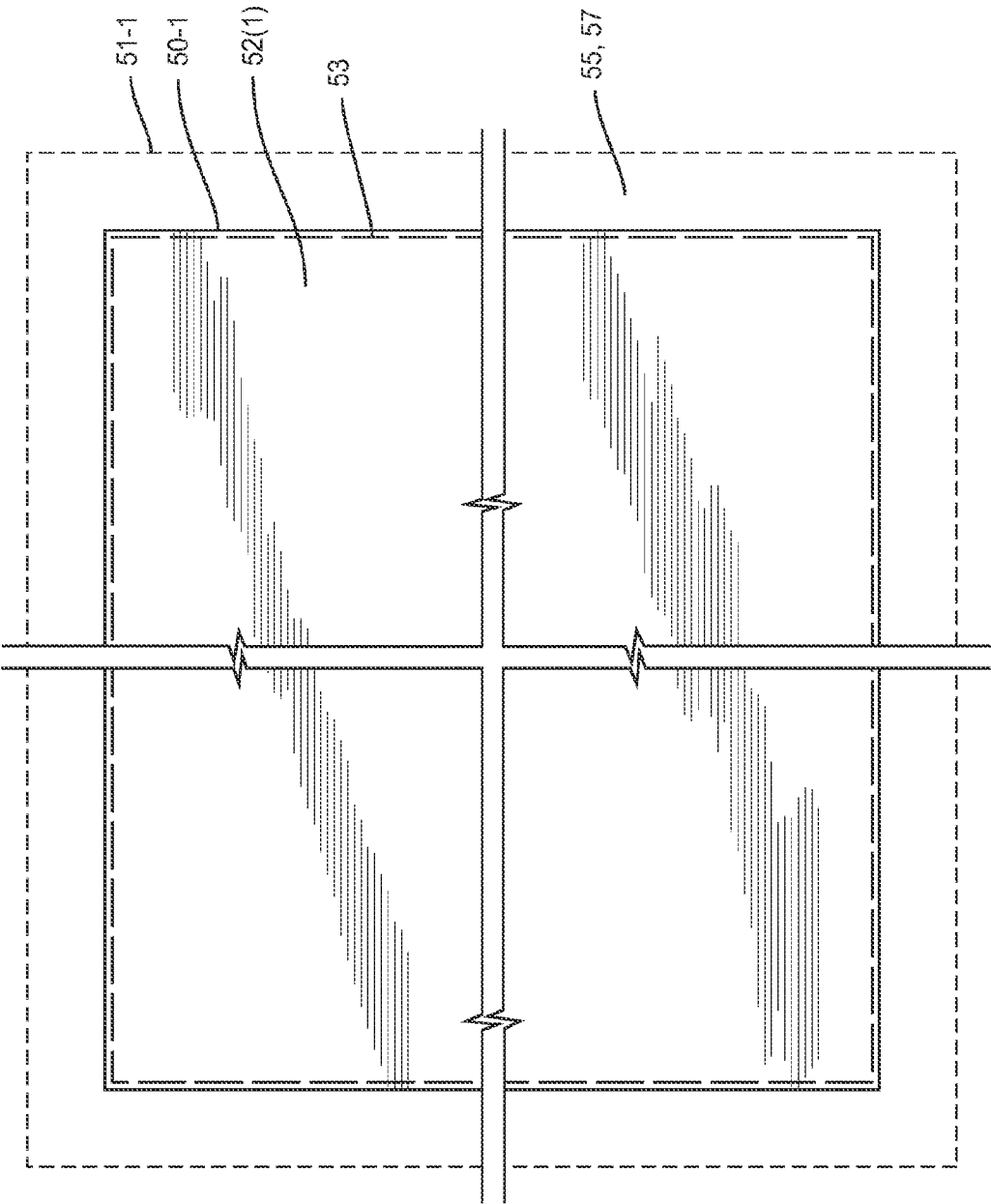


FIG. 5

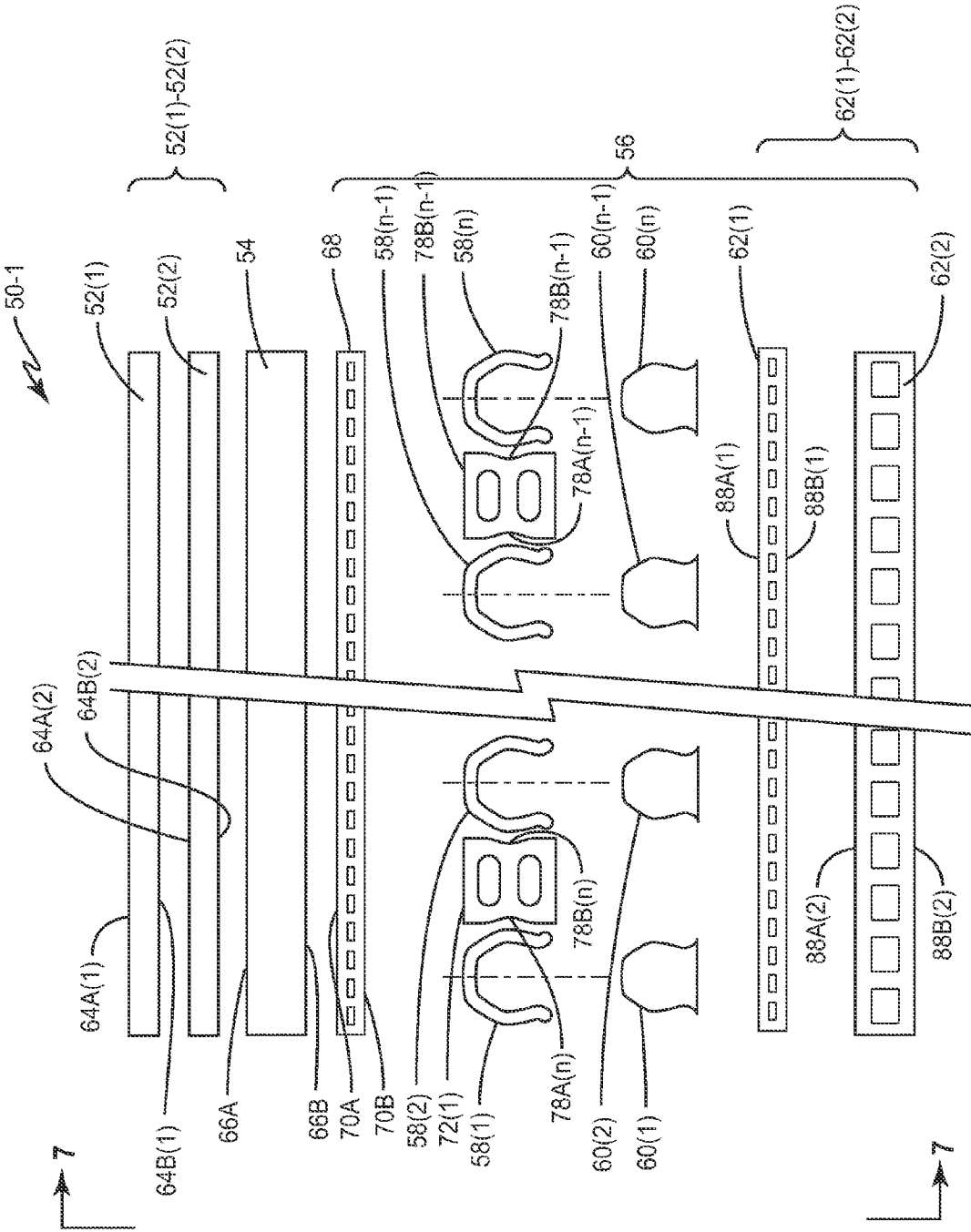


FIG. 6

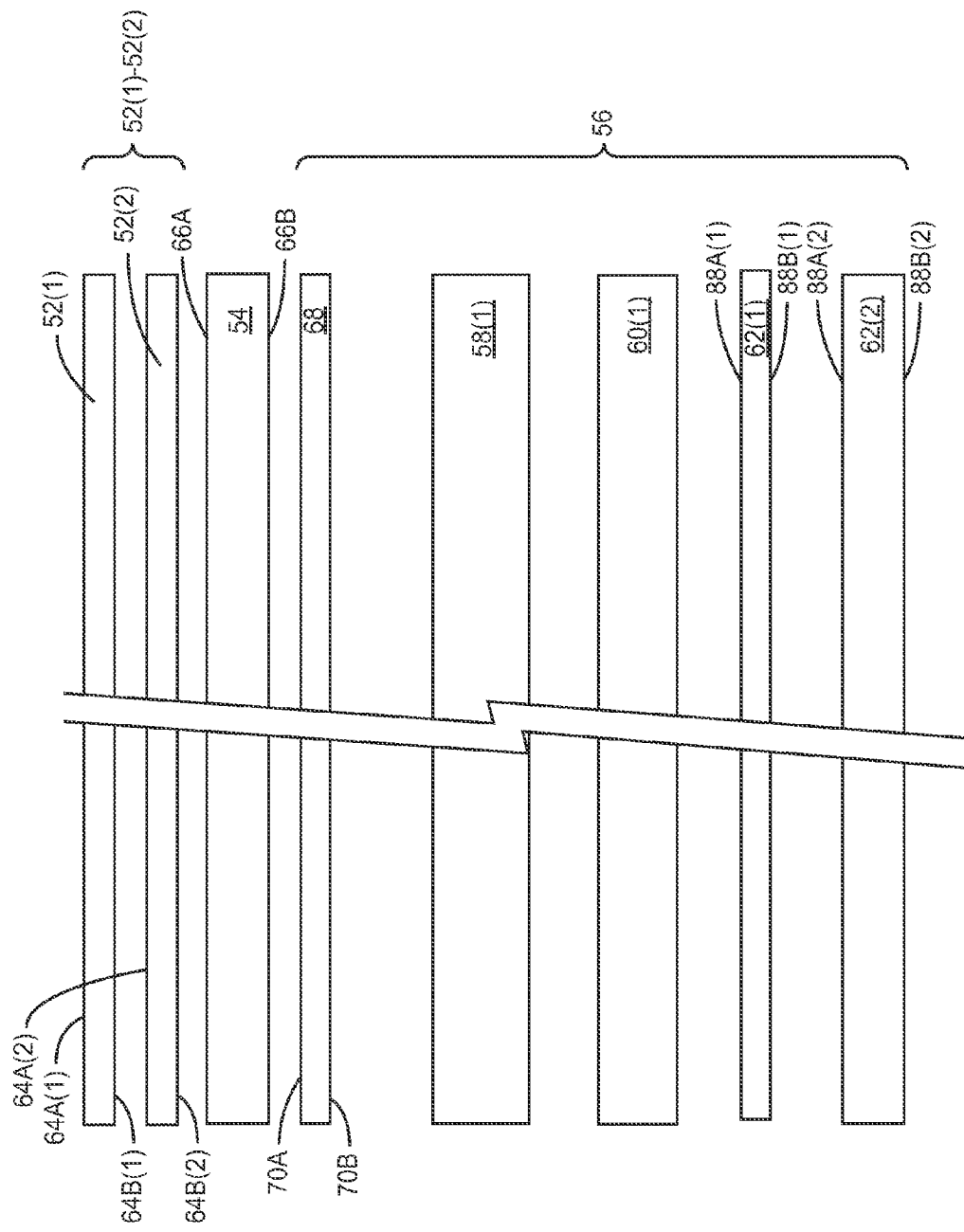


FIG. 7

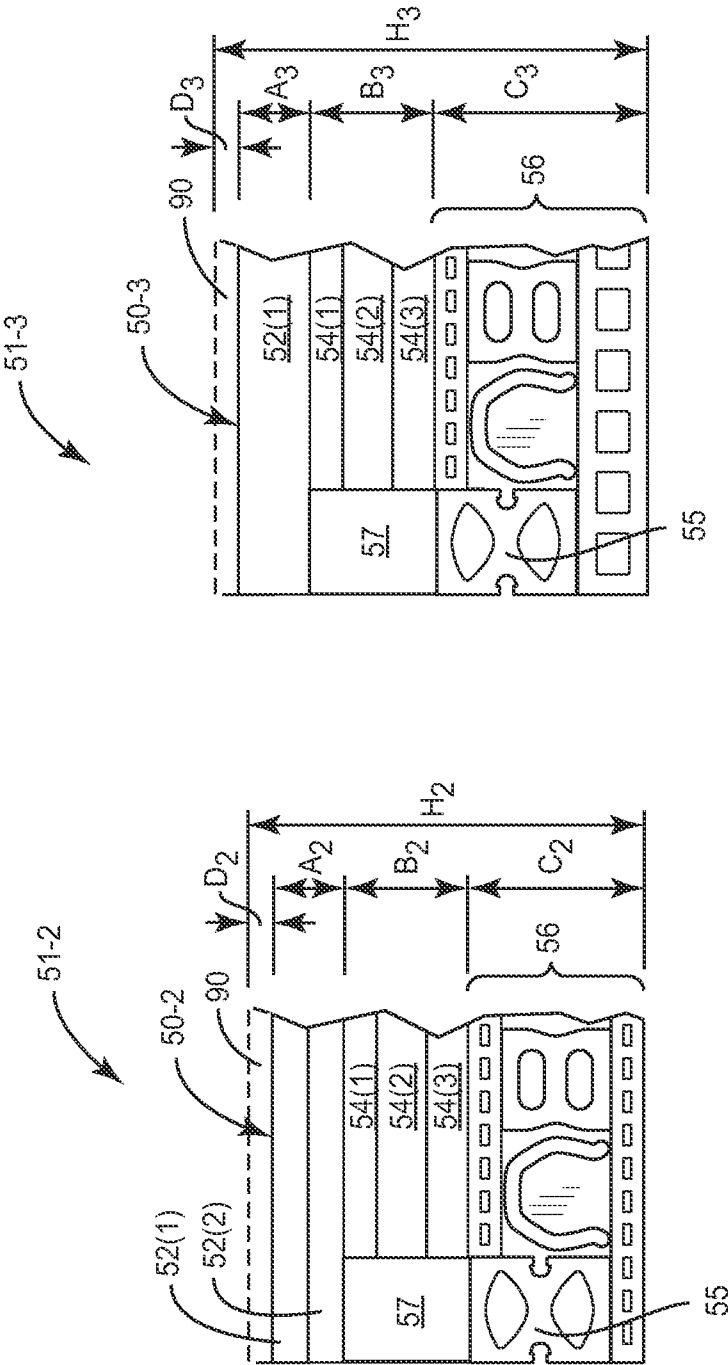


FIG. 8B

FIG. 8A

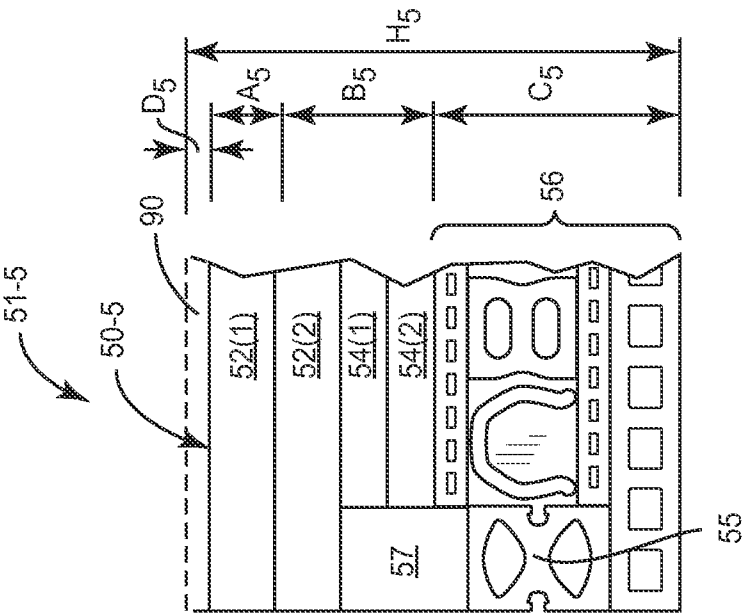


FIG. 8C

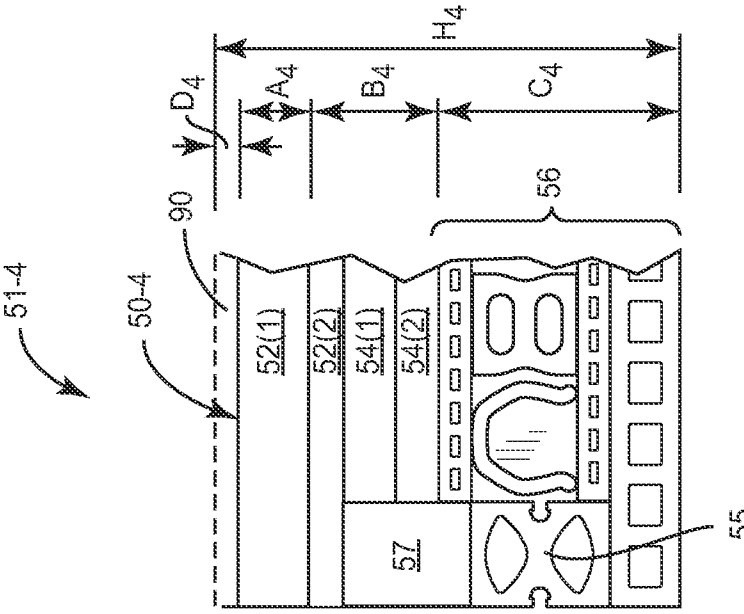


FIG. 8D

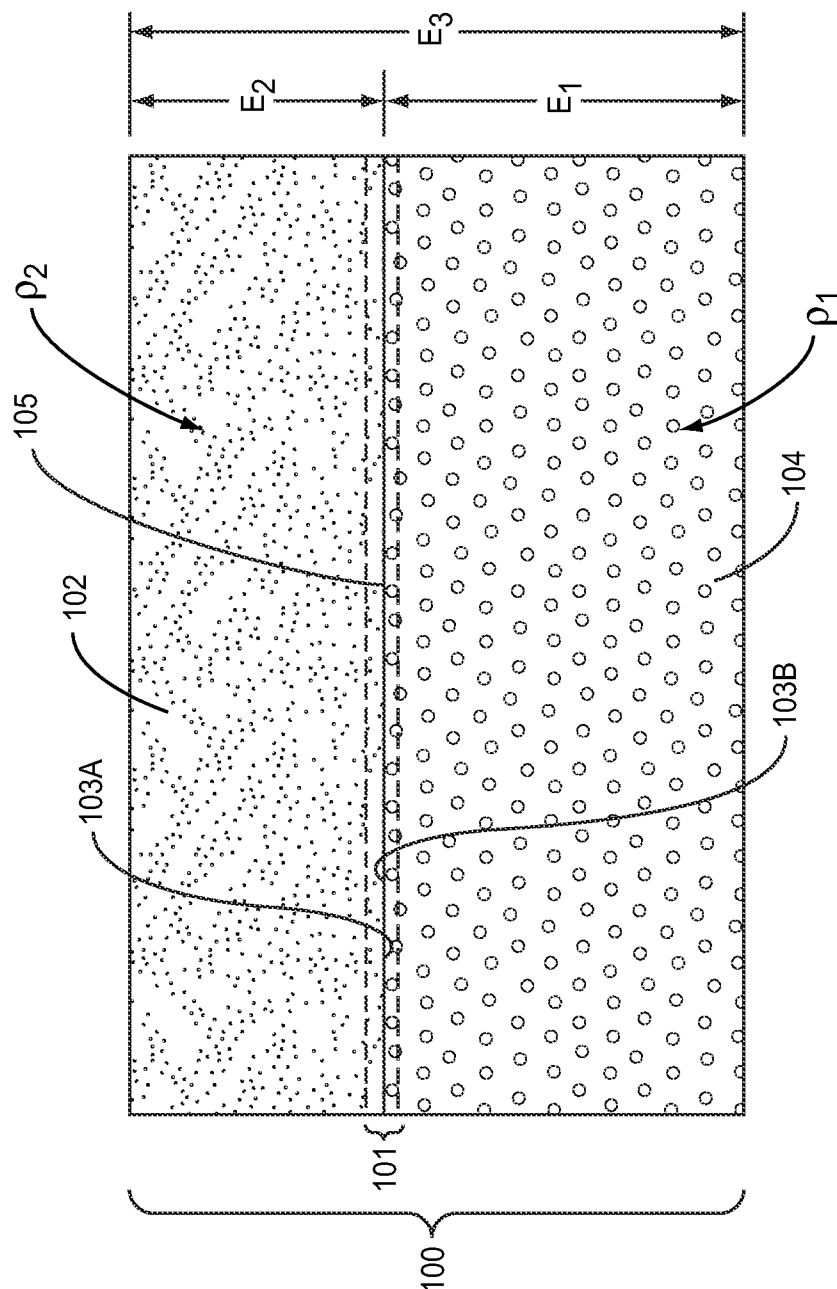


FIG. 9A

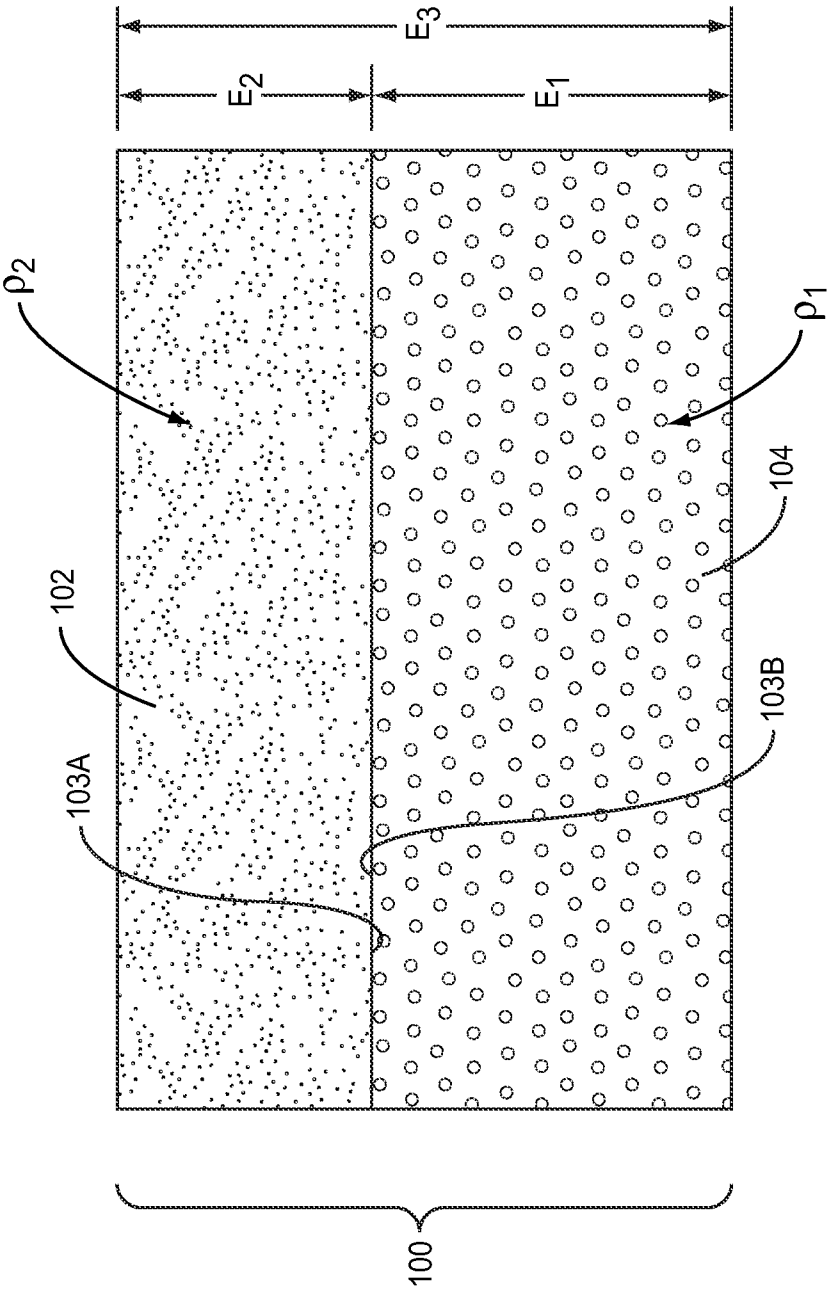


FIG. 9B

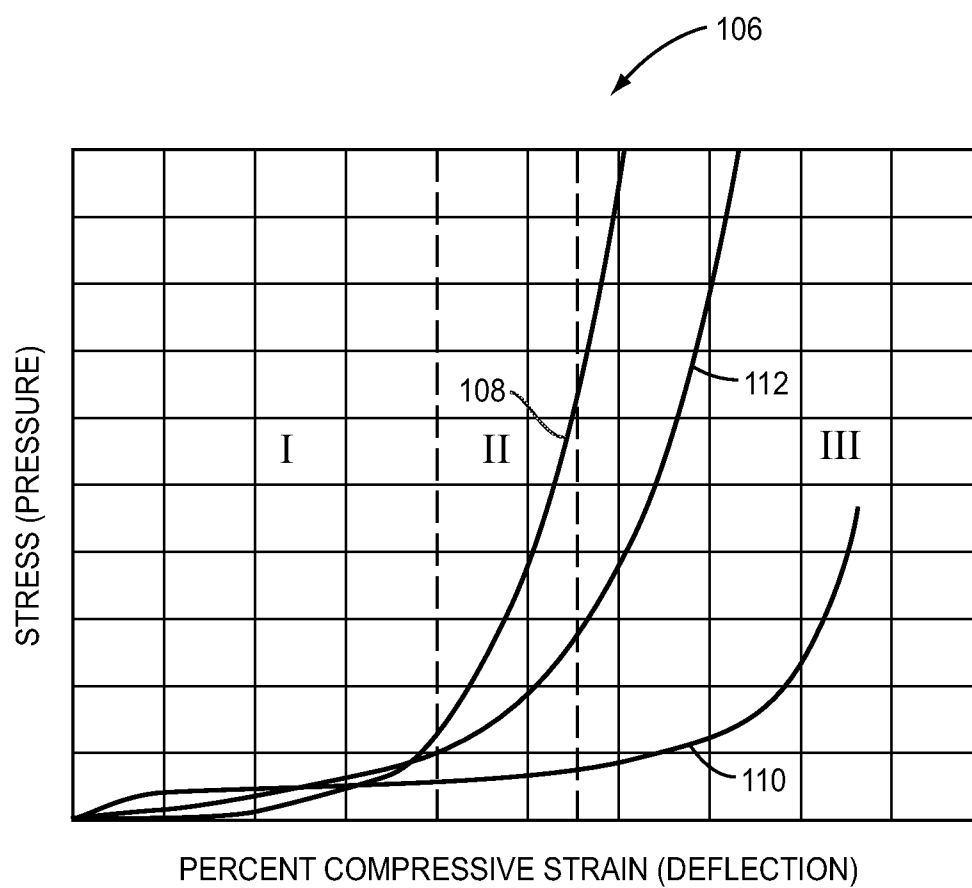


FIG. 10

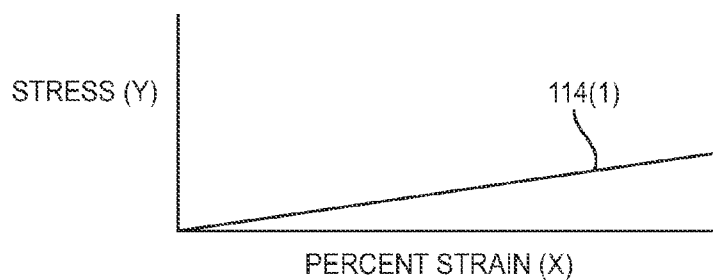


FIG. 11A

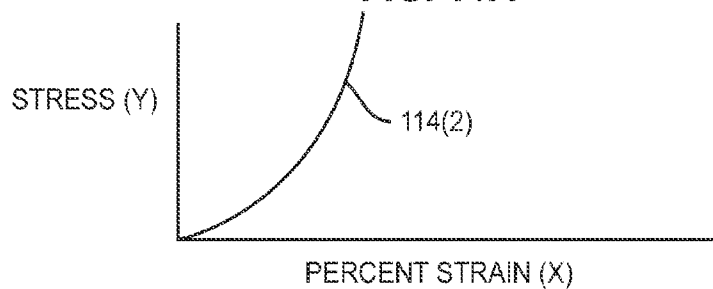


FIG. 11B

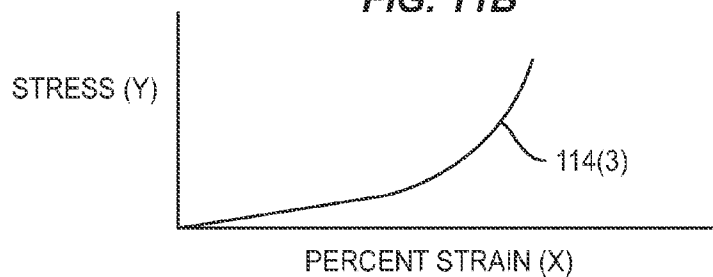


FIG. 11C

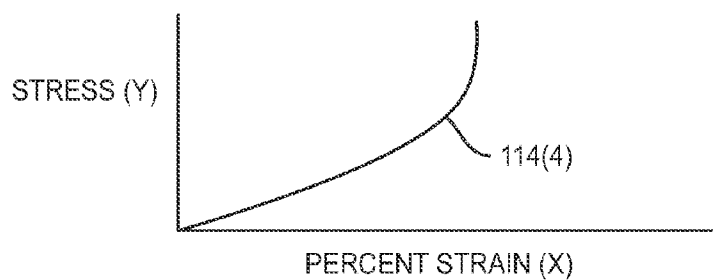


FIG. 11D

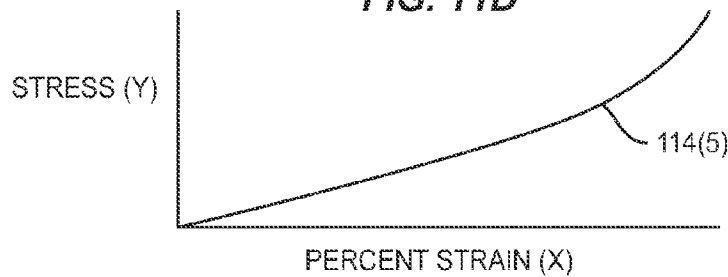


FIG. 11E

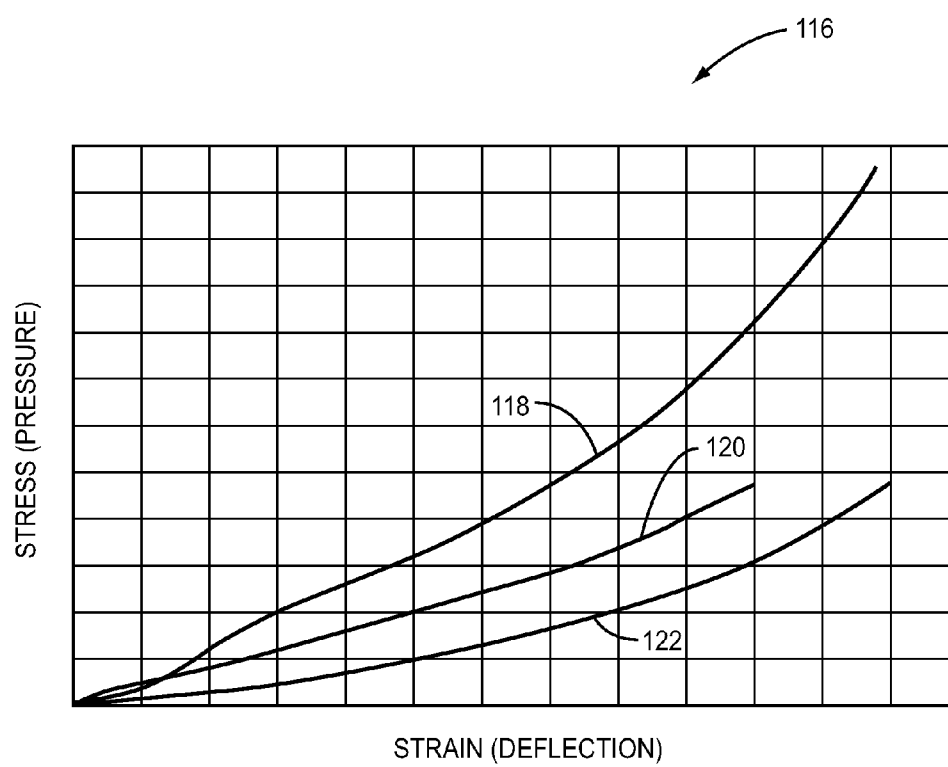
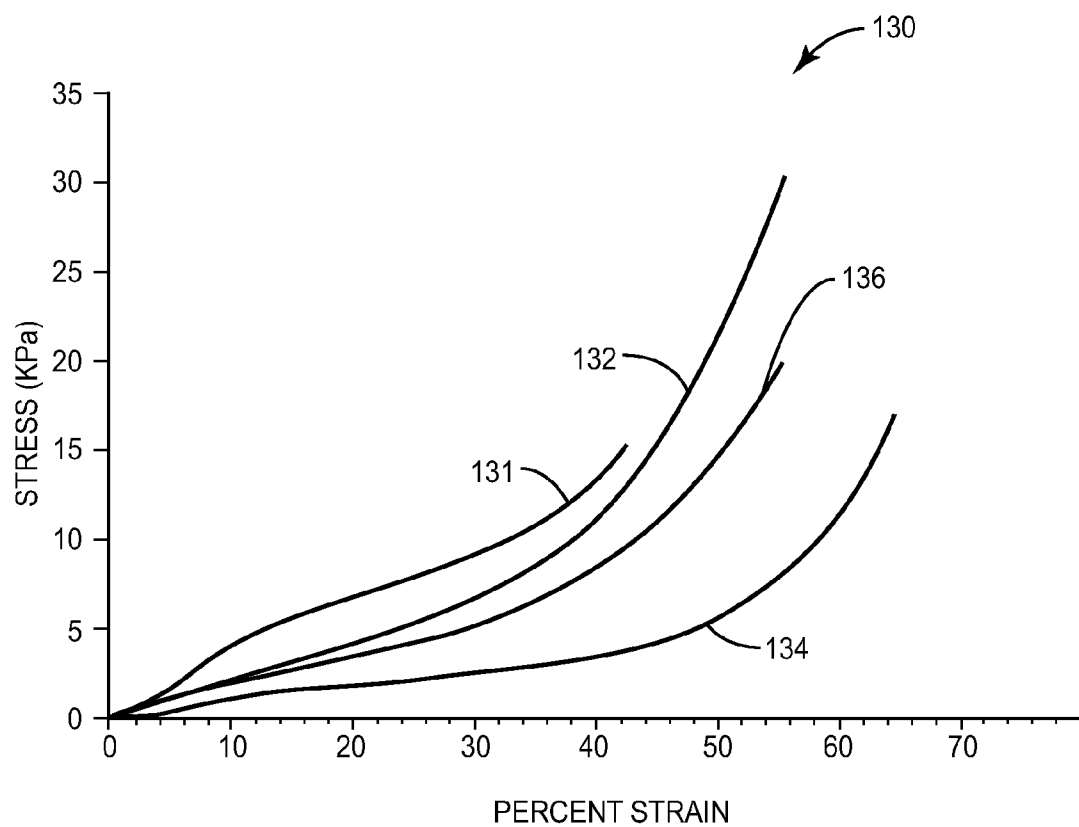


FIG. 12

**FIG. 13**

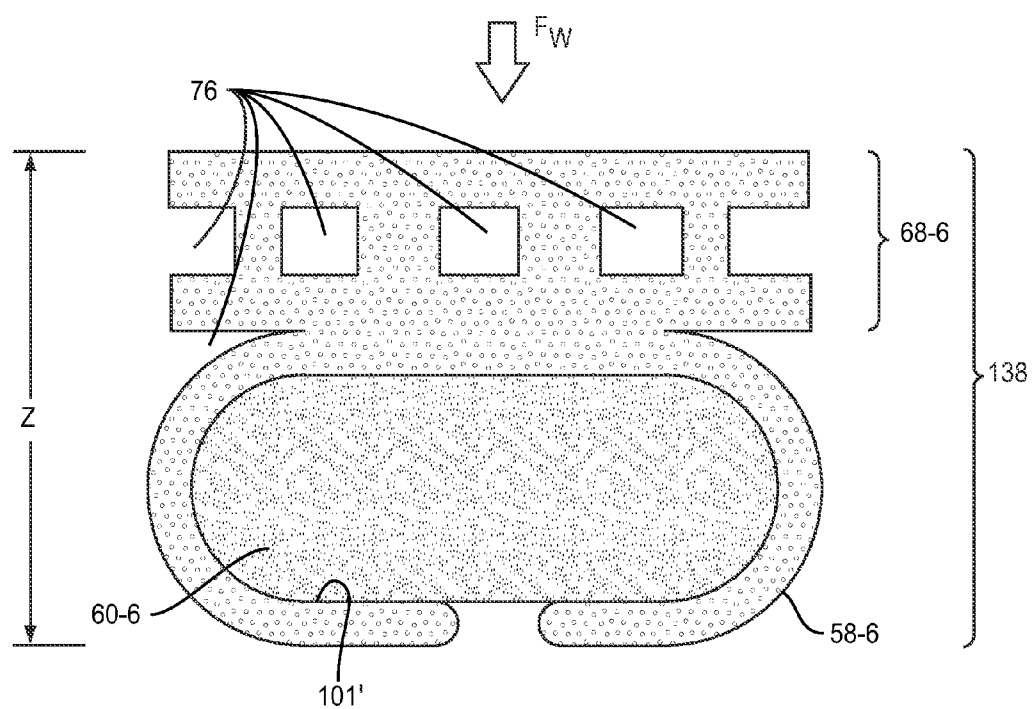


FIG. 14

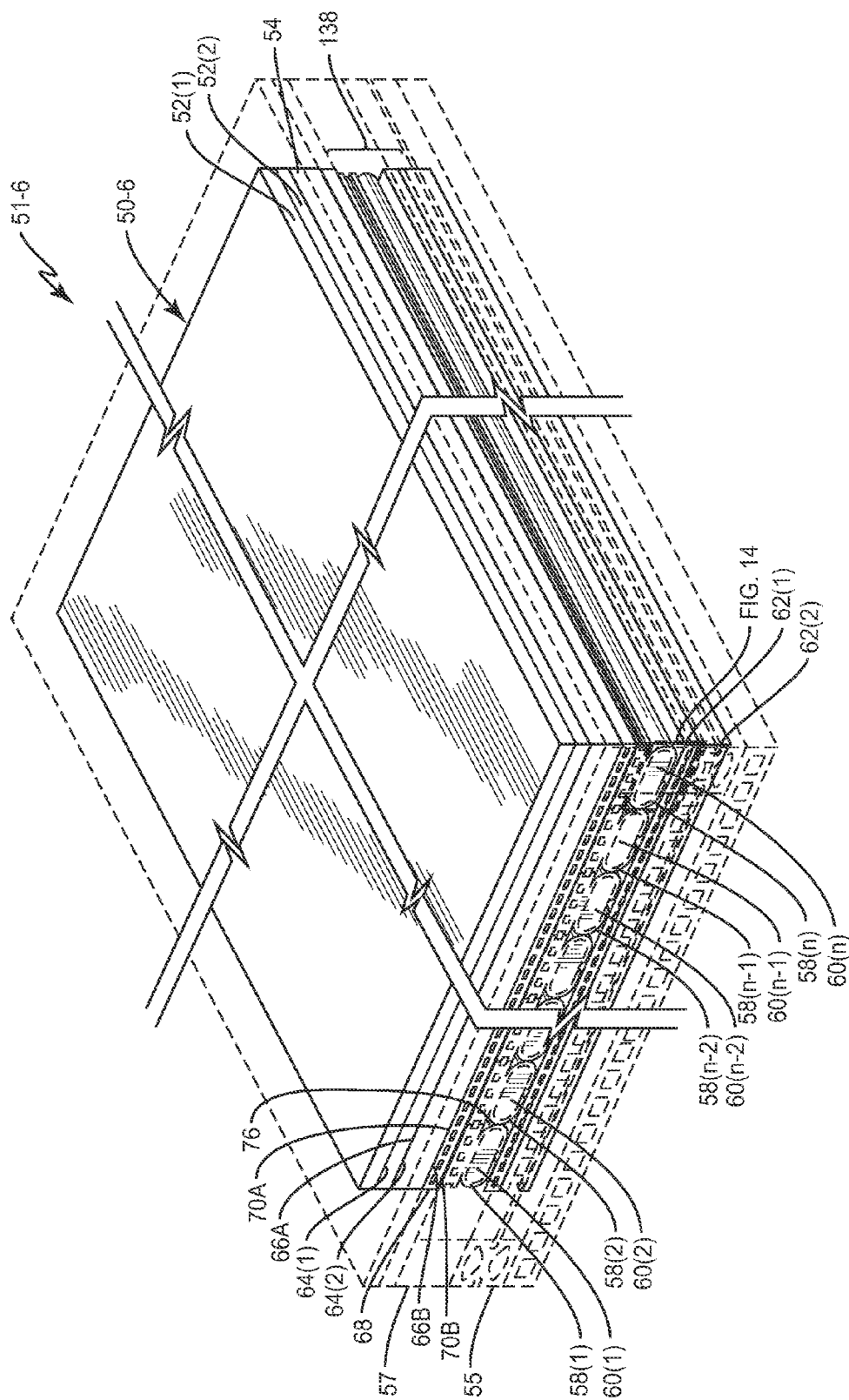
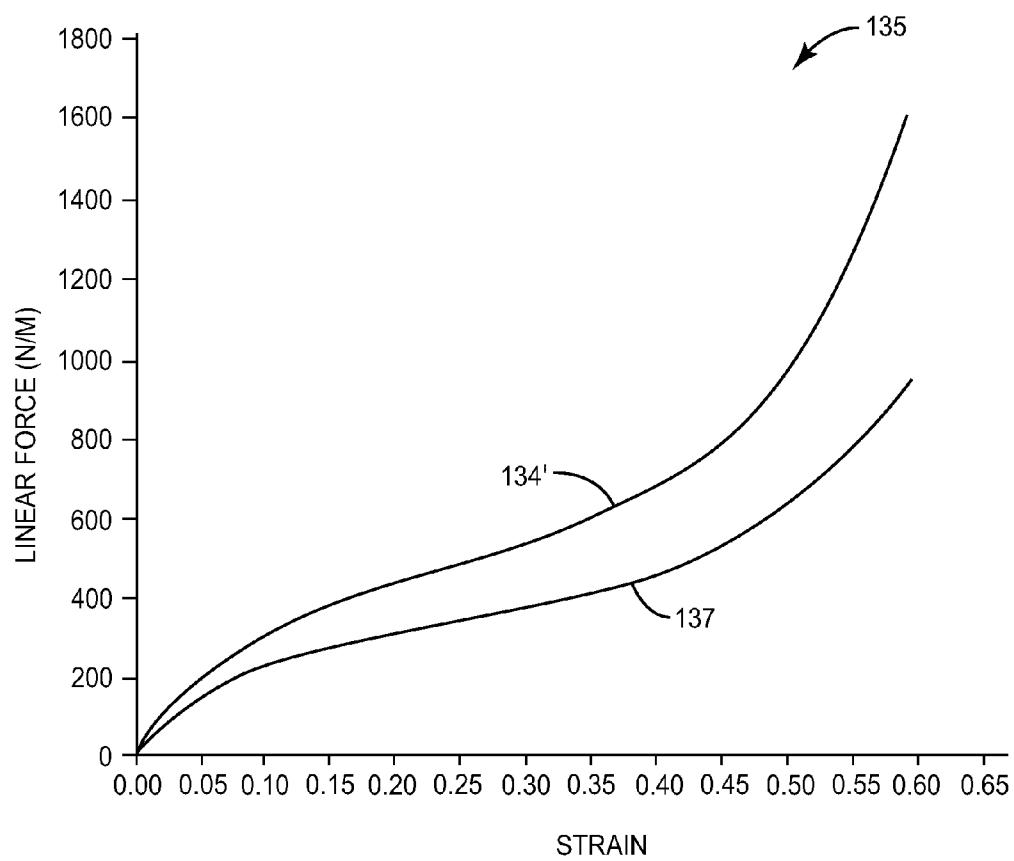


FIG. 15A

**FIG. 15B**

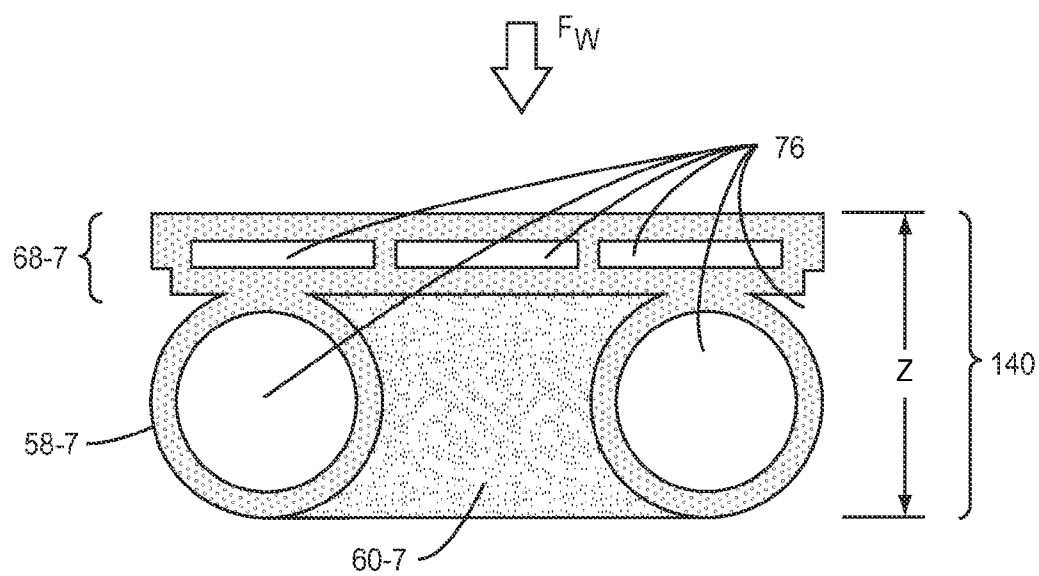


FIG. 16

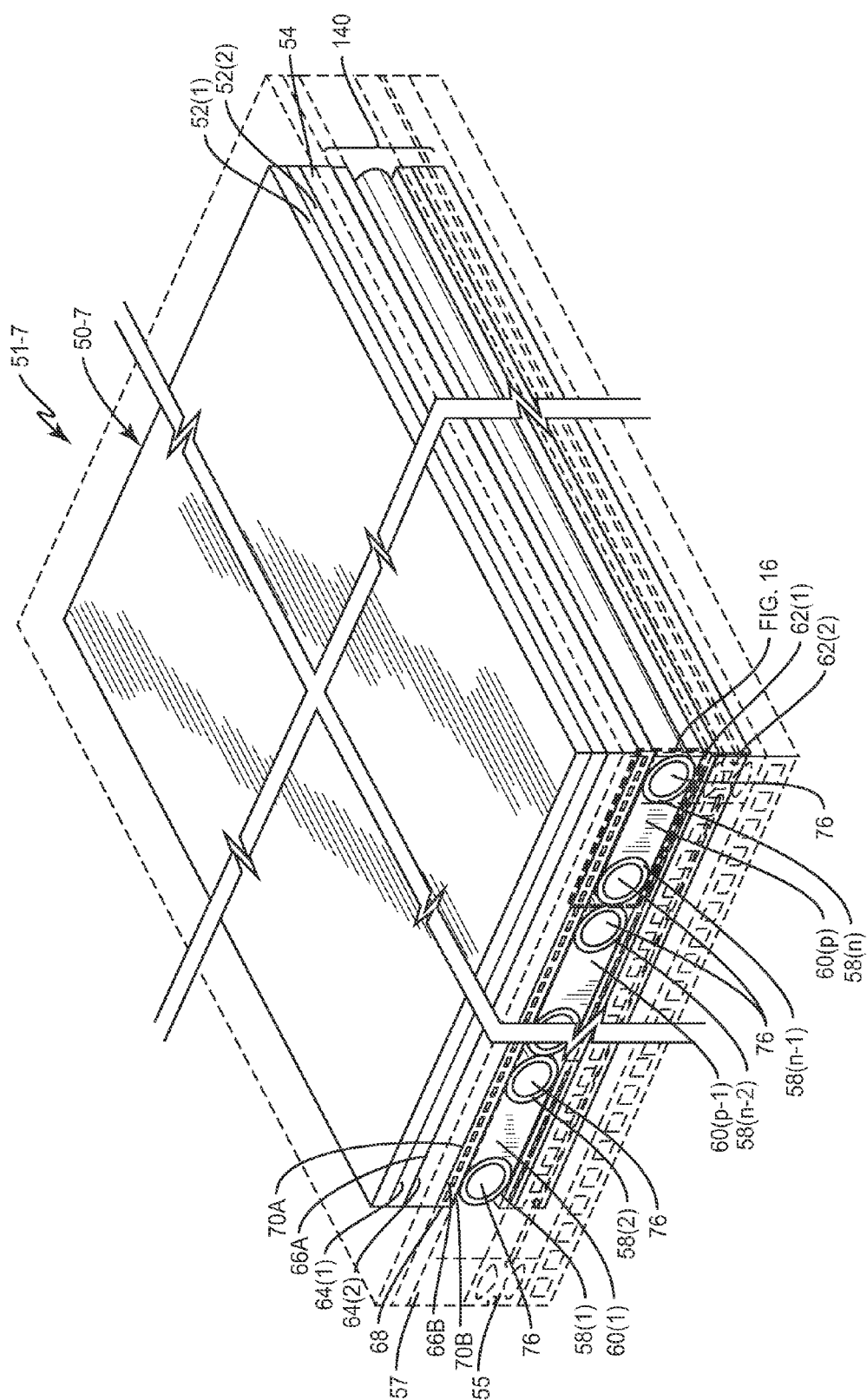


FIG. 17

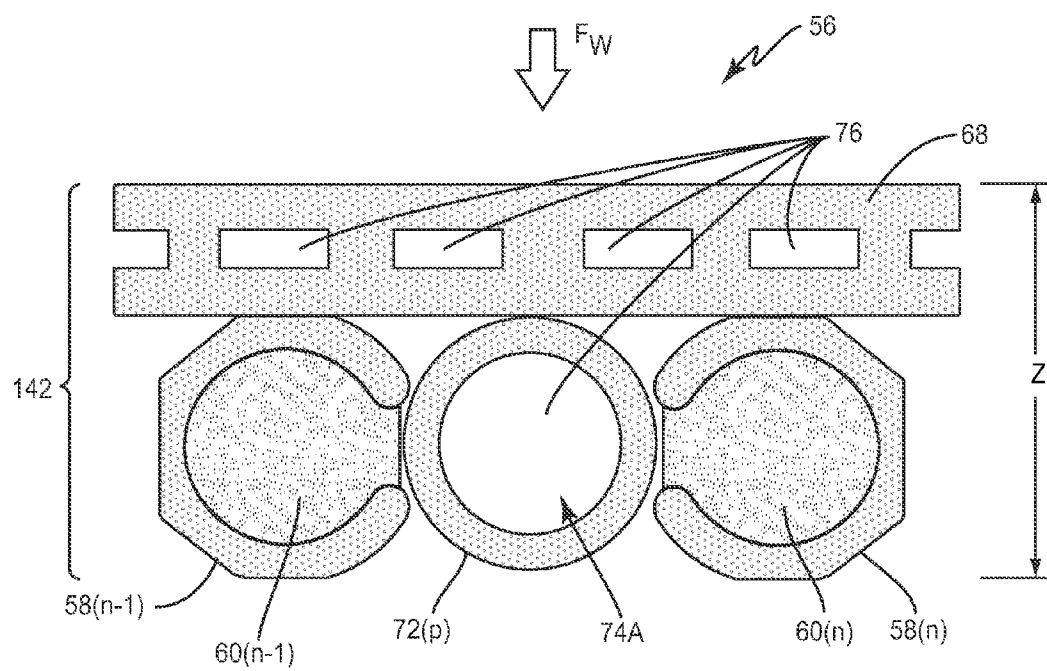


FIG. 18

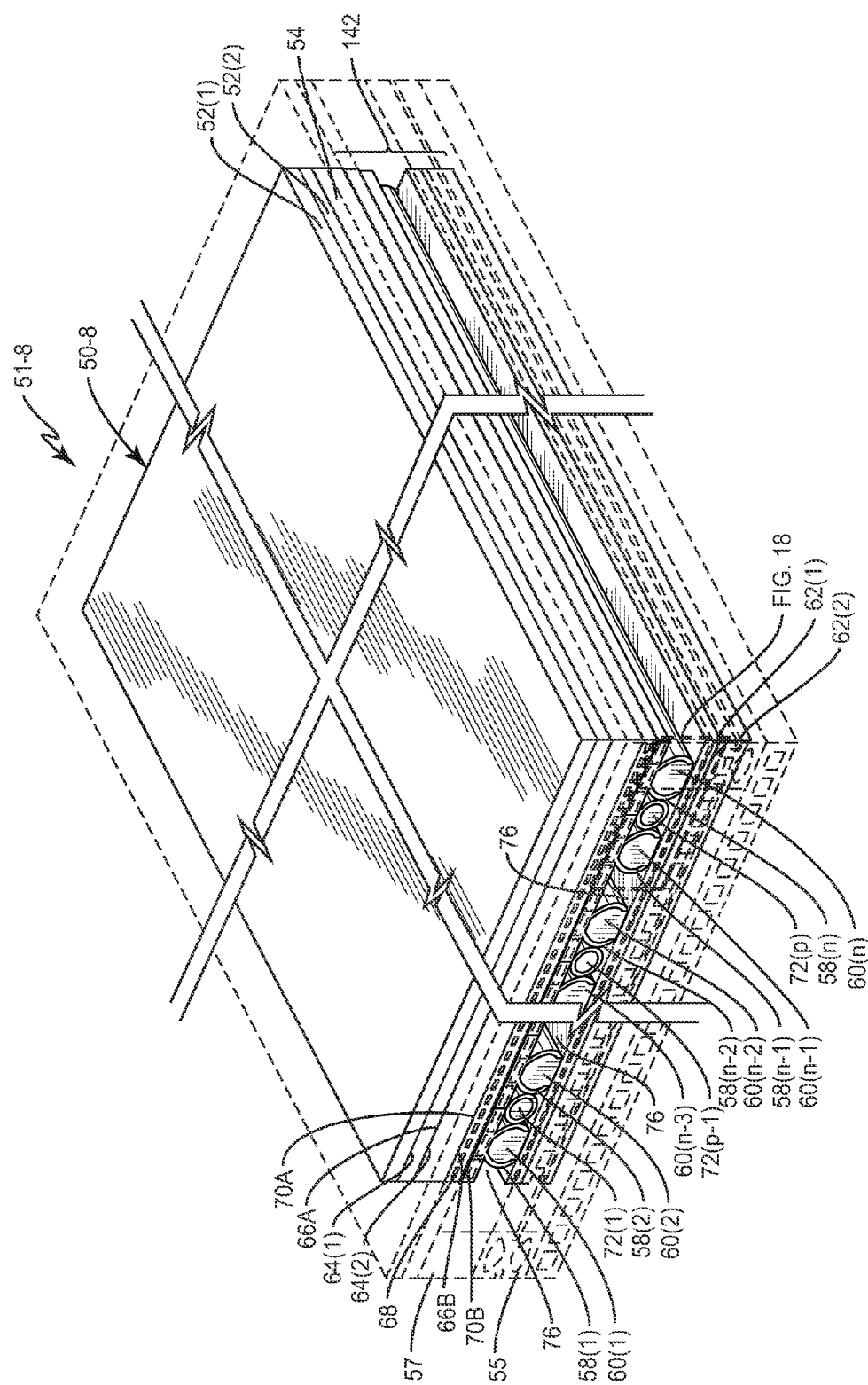


FIG. 19

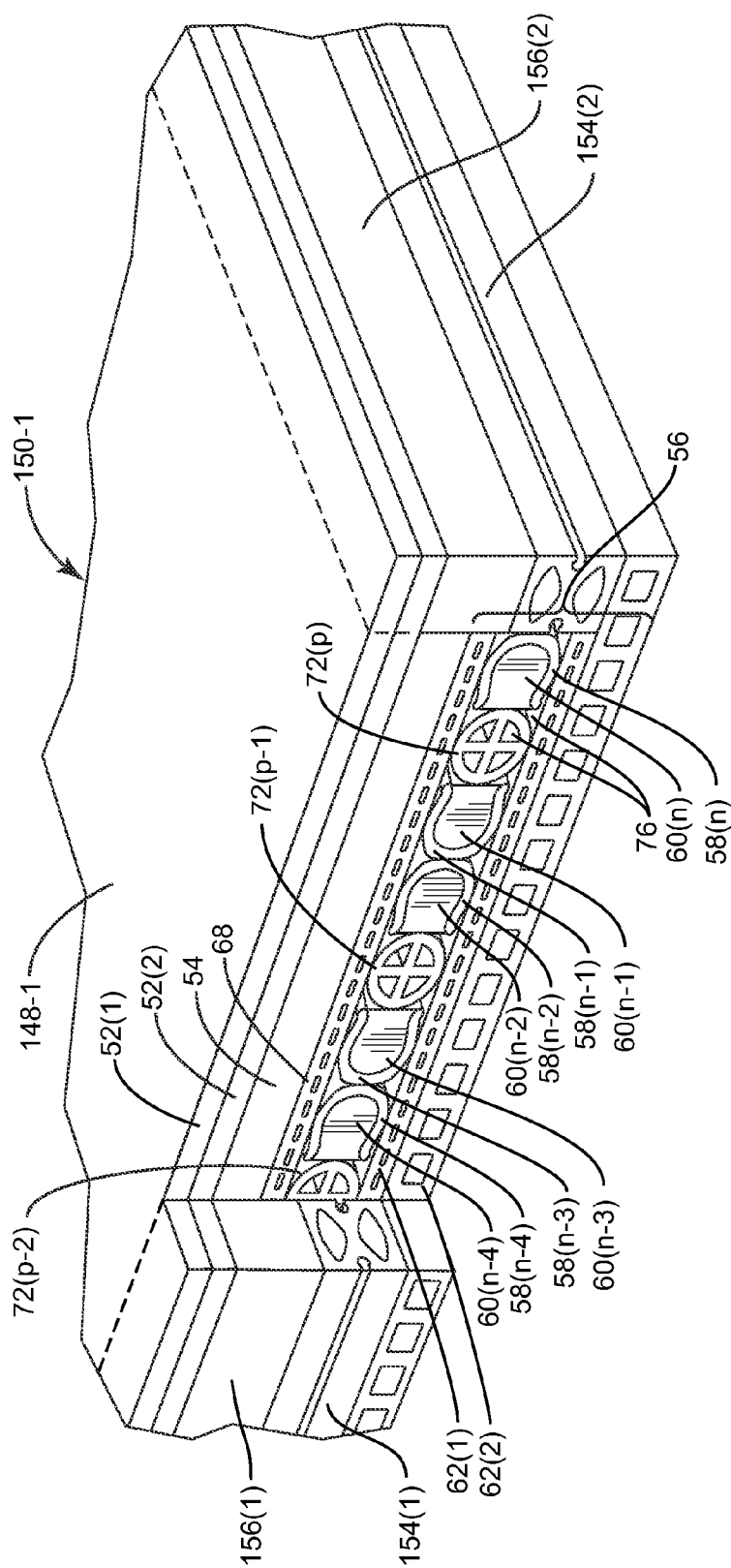


FIG. 20

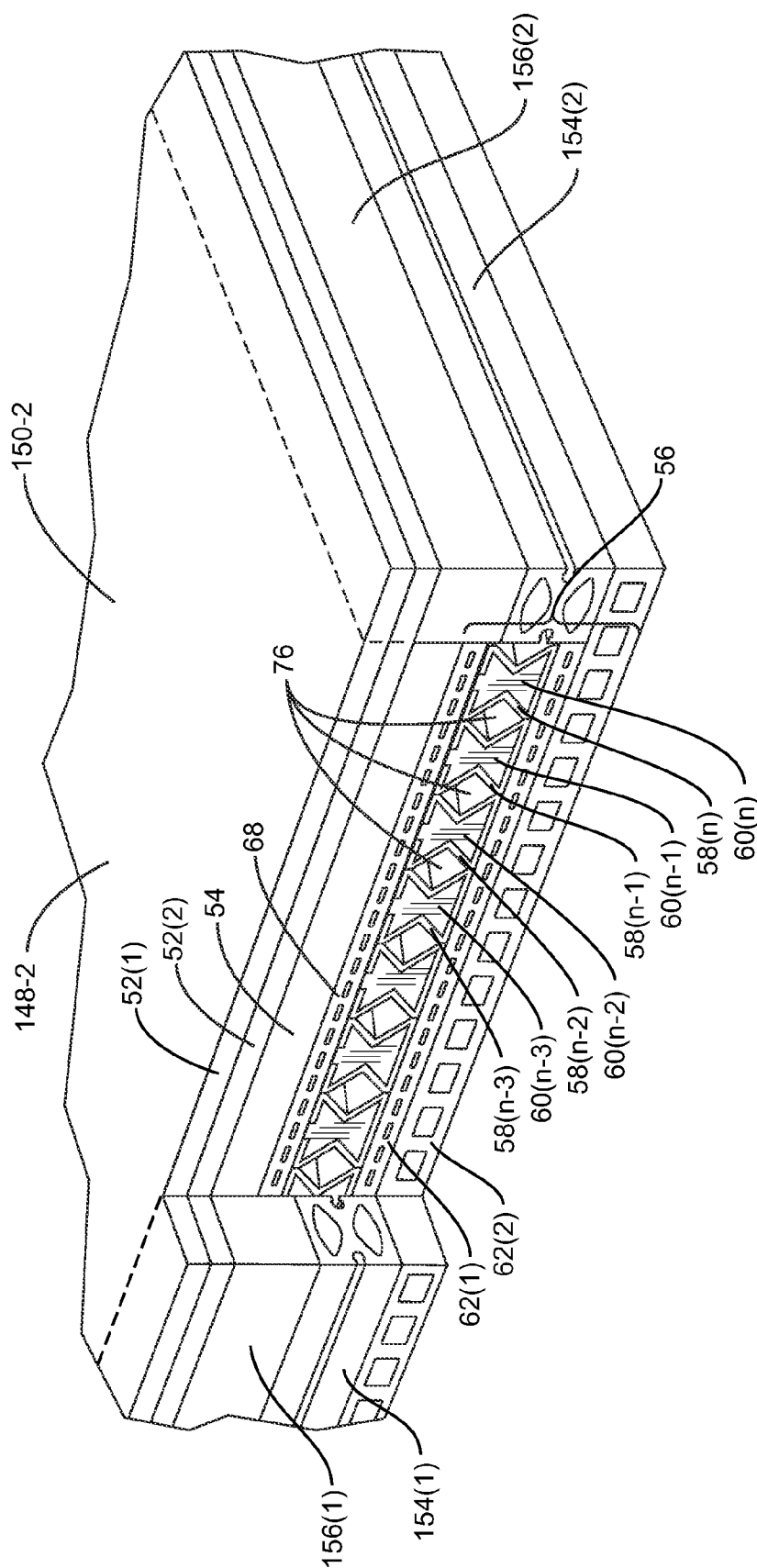


FIG. 21

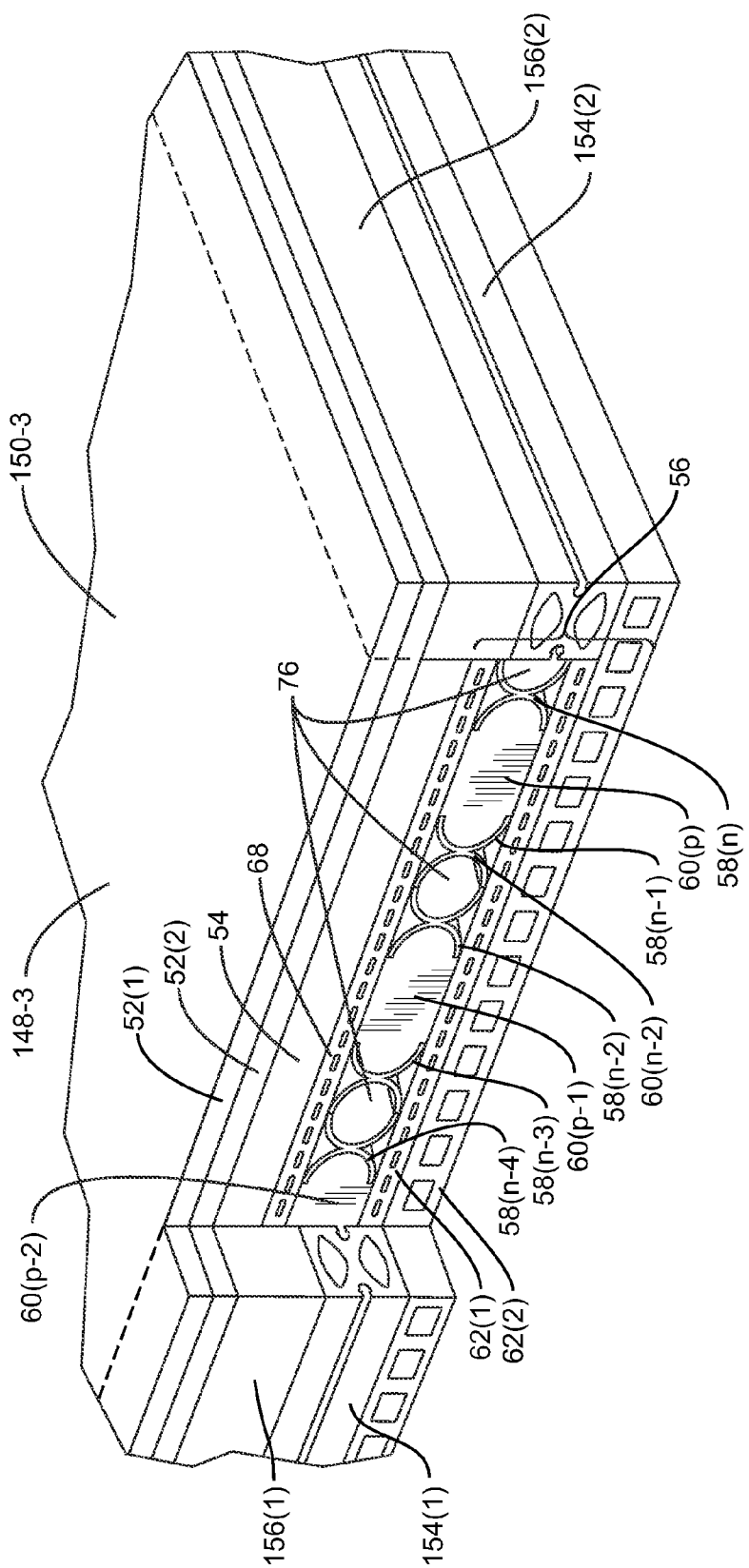


FIG. 22

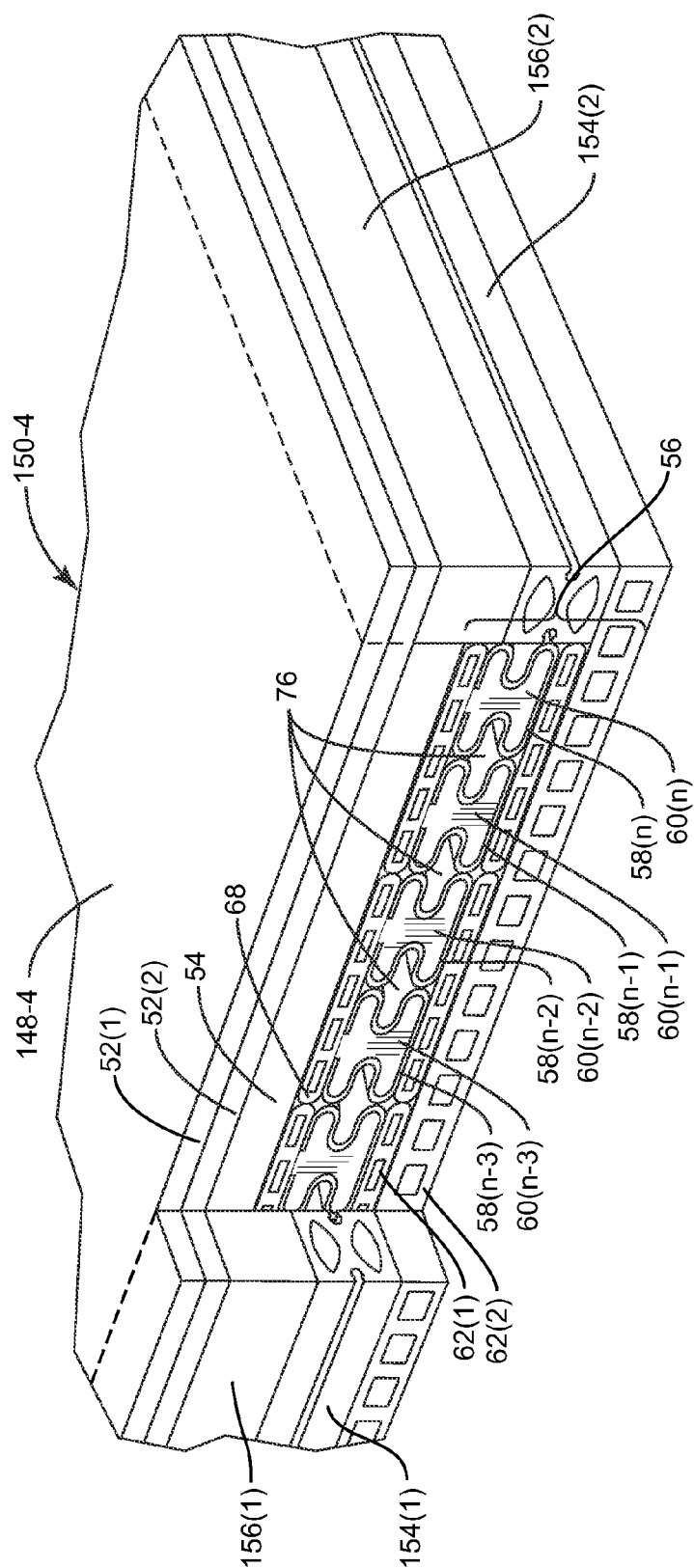


FIG. 23

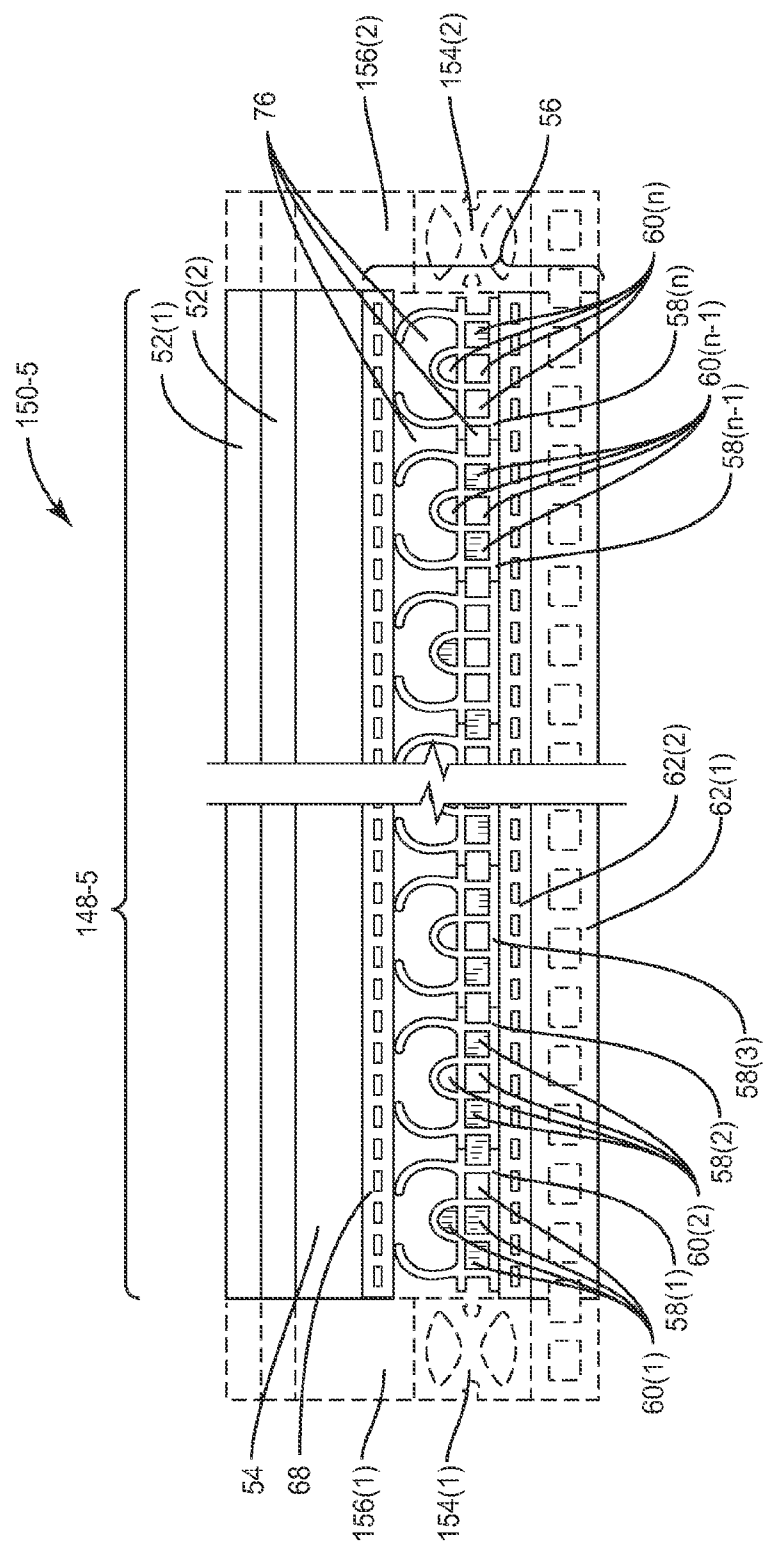


FIG. 24

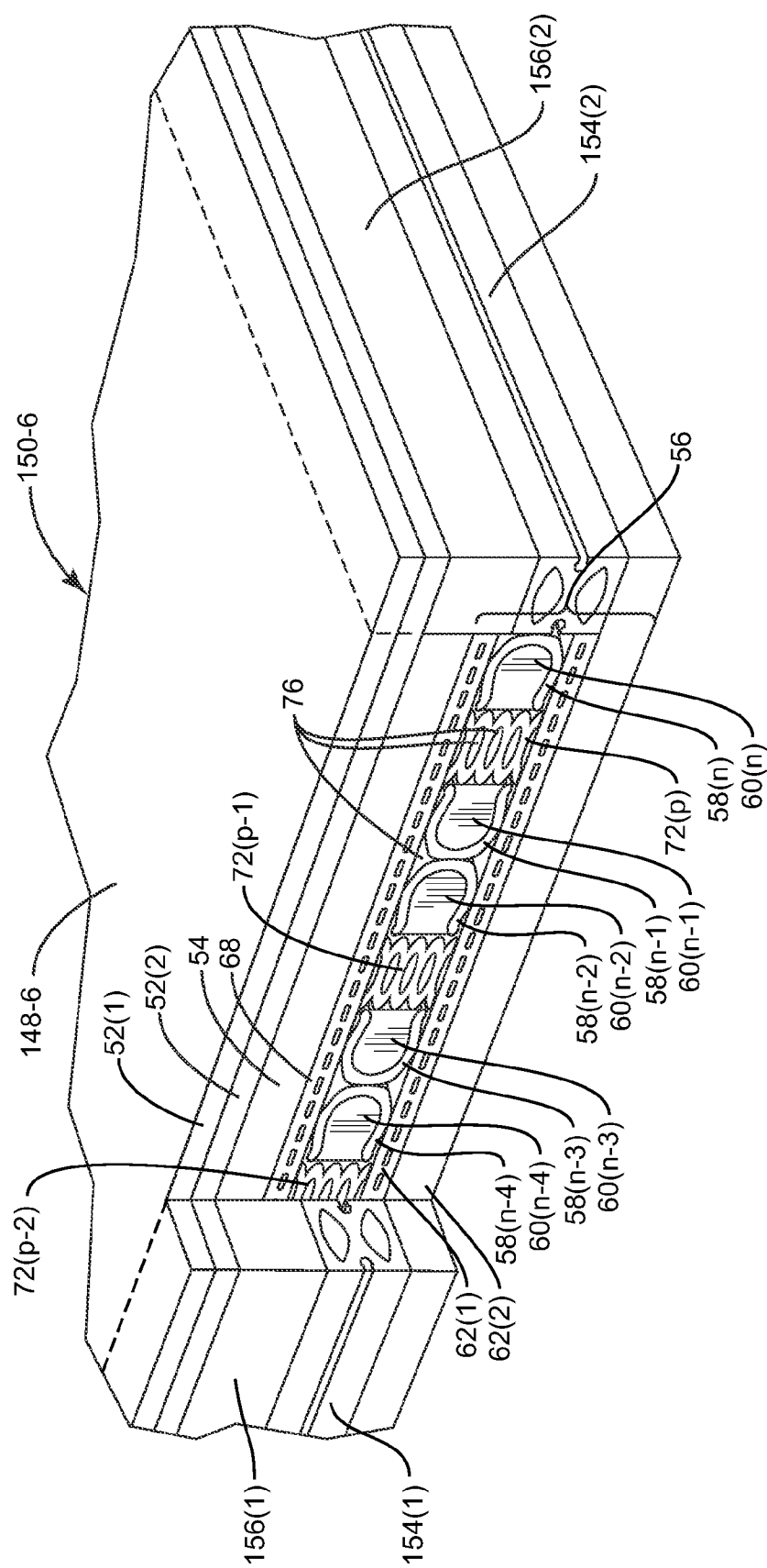


FIG. 25

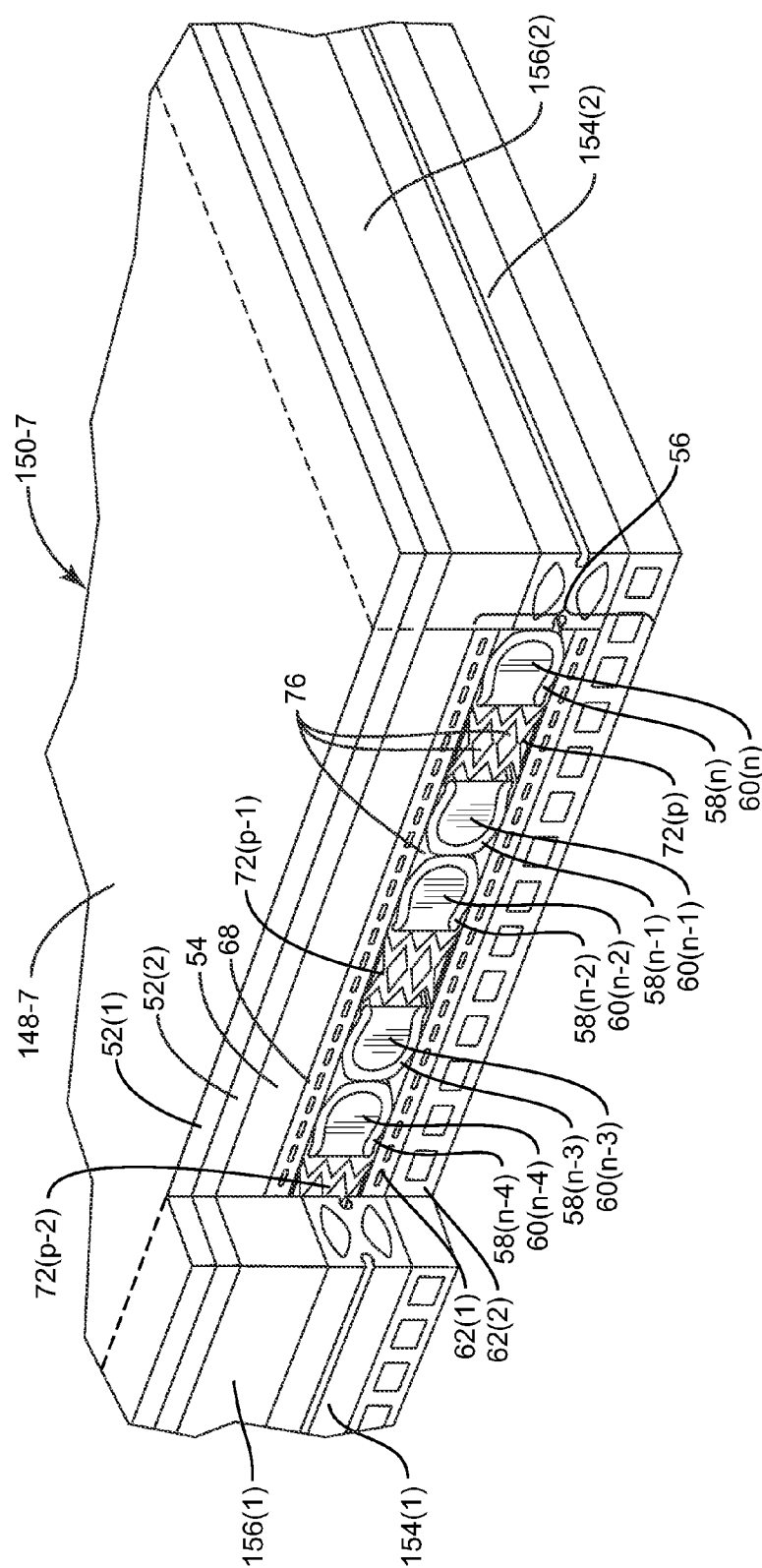


FIG. 26

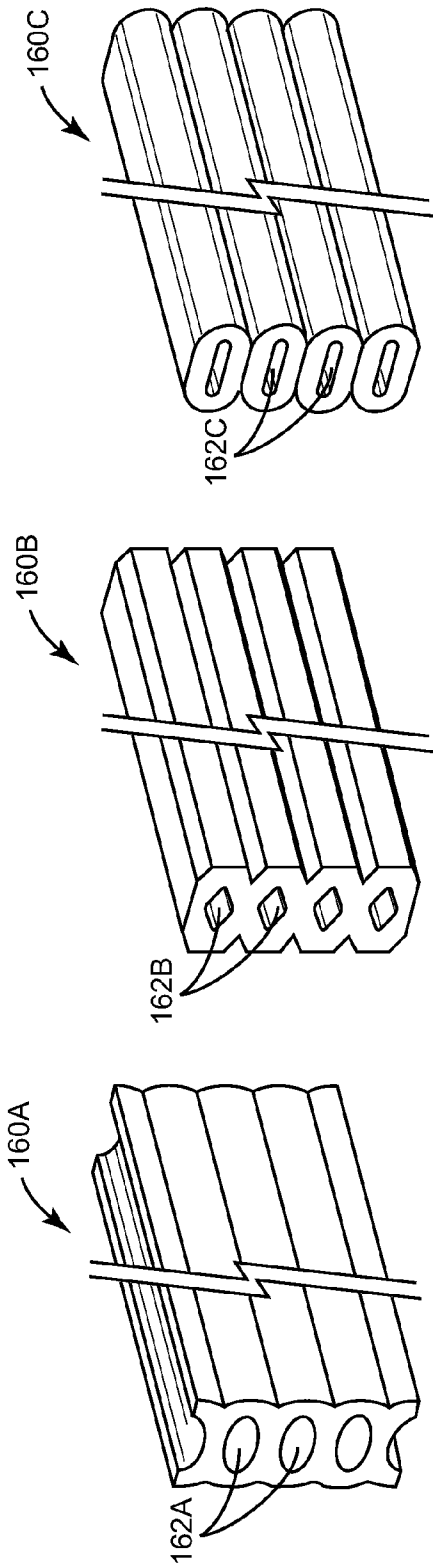


FIG. 27C

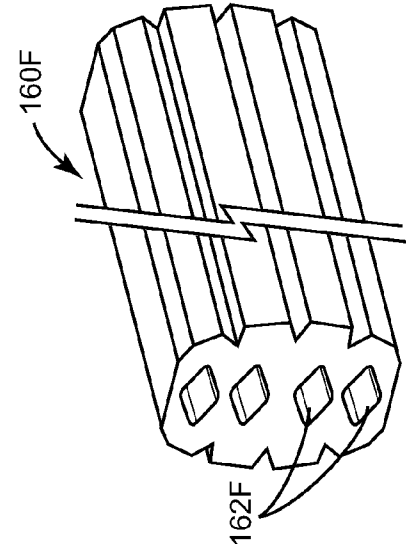


FIG. 27F

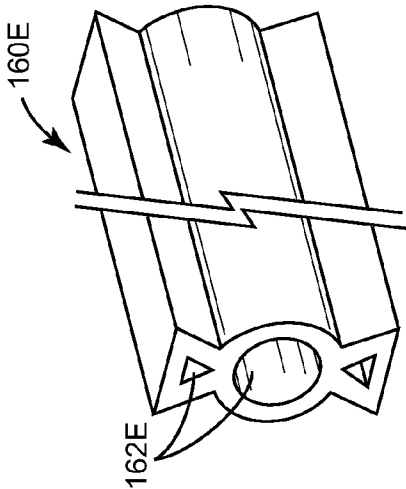


FIG. 27E

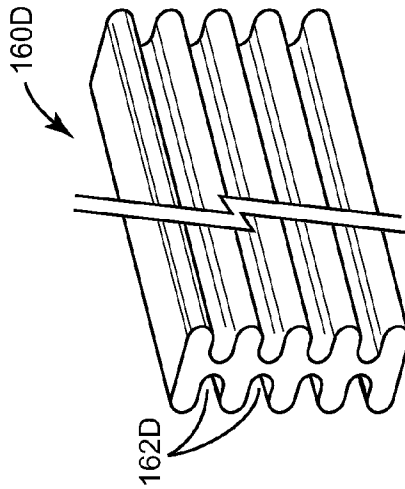


FIG. 27D

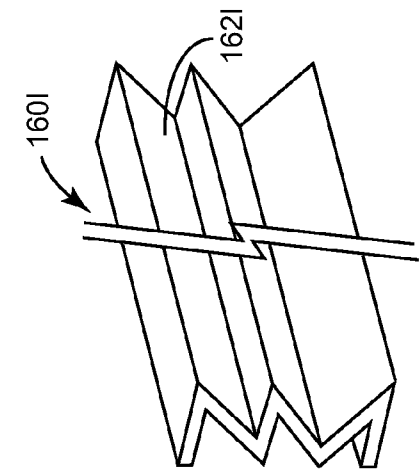


FIG. 27I

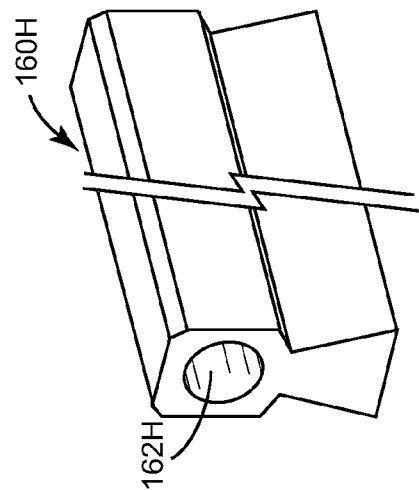


FIG. 27H

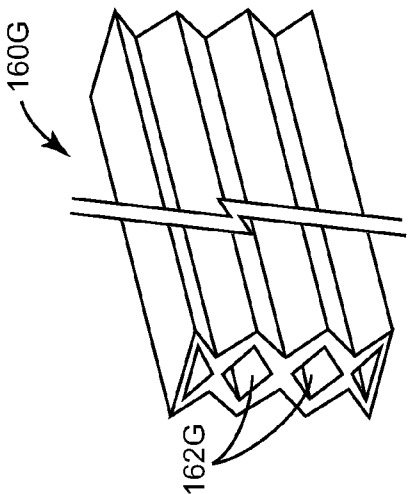


FIG. 27G

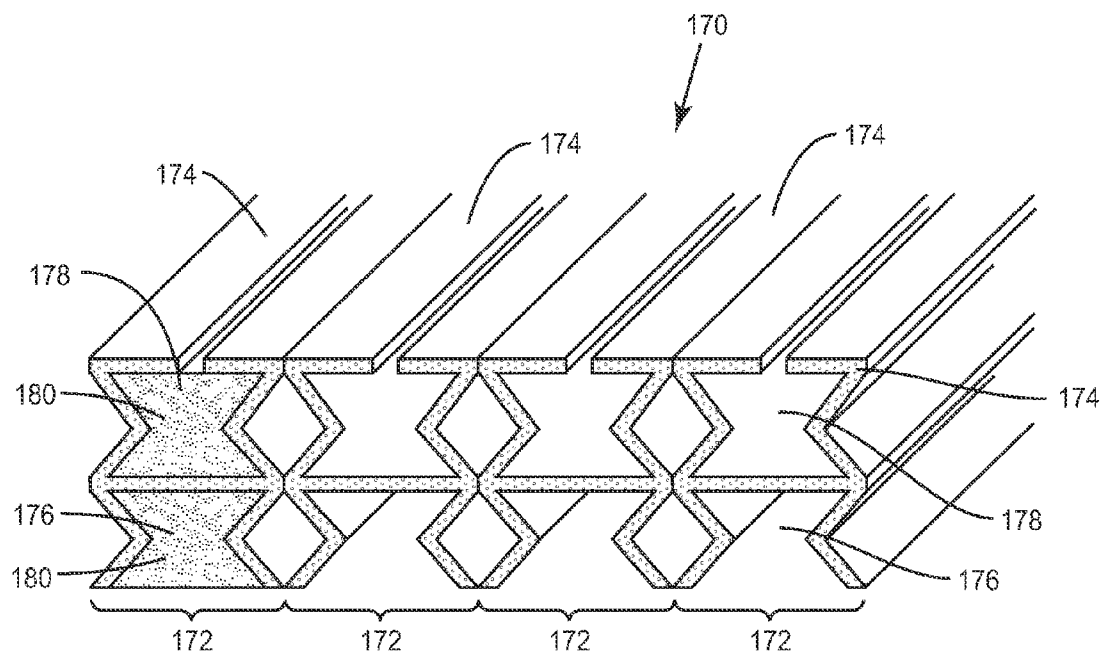


FIG. 28A

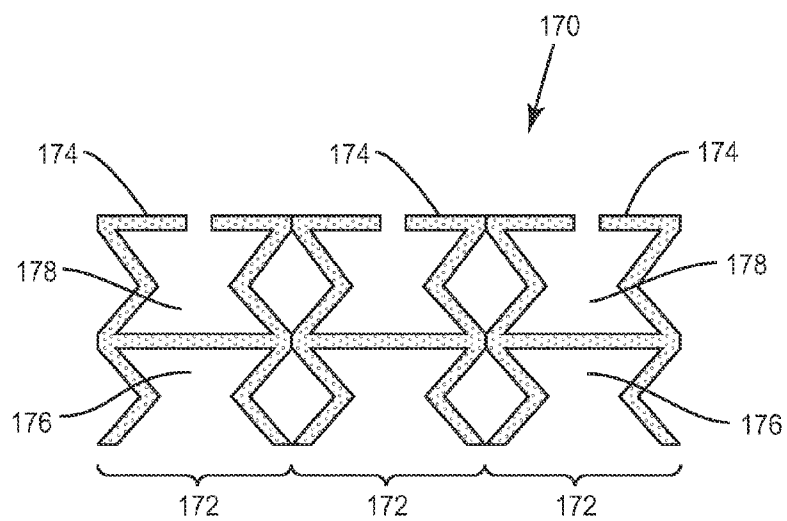


FIG. 28B

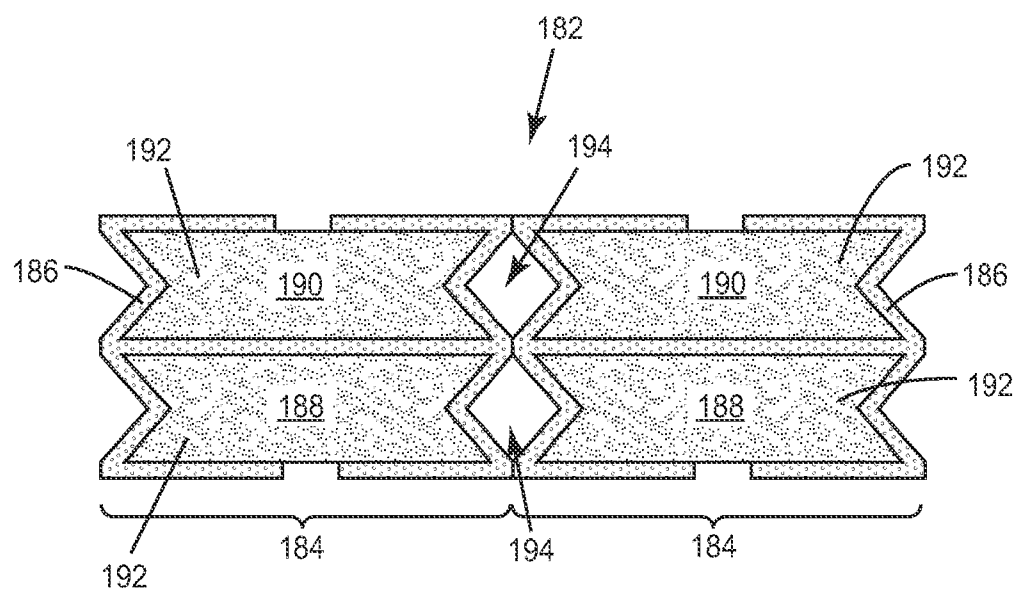


FIG. 28C

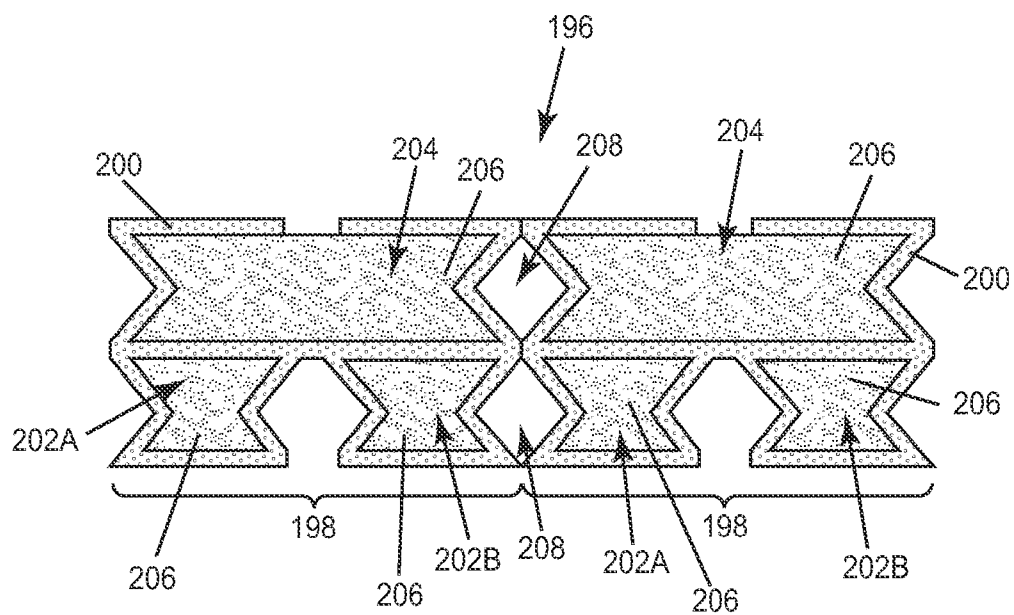


FIG. 28D

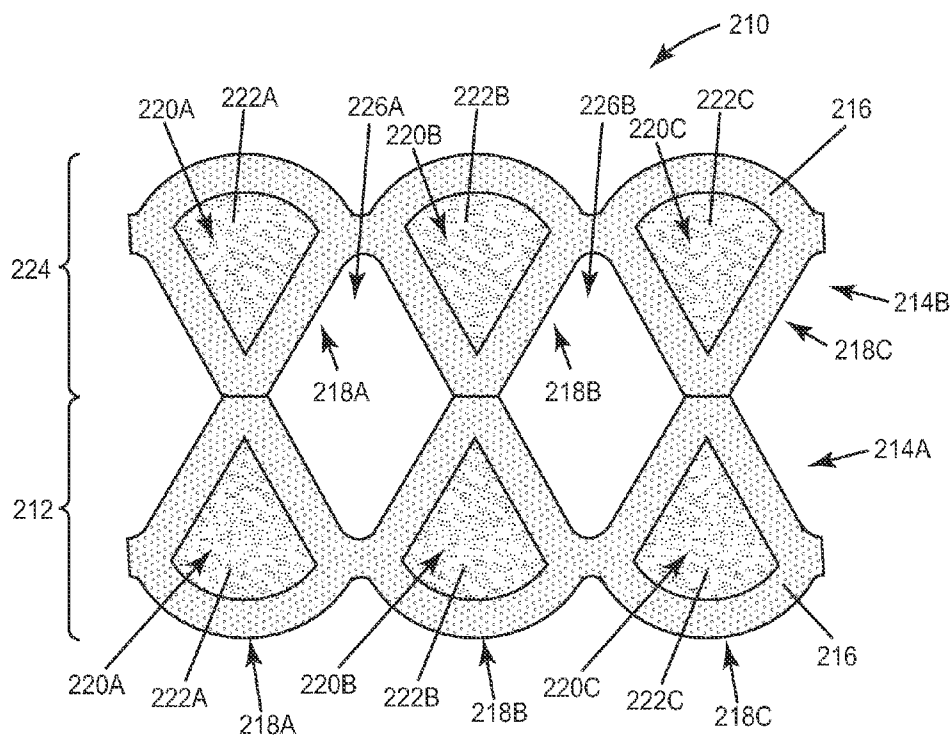


FIG. 29A

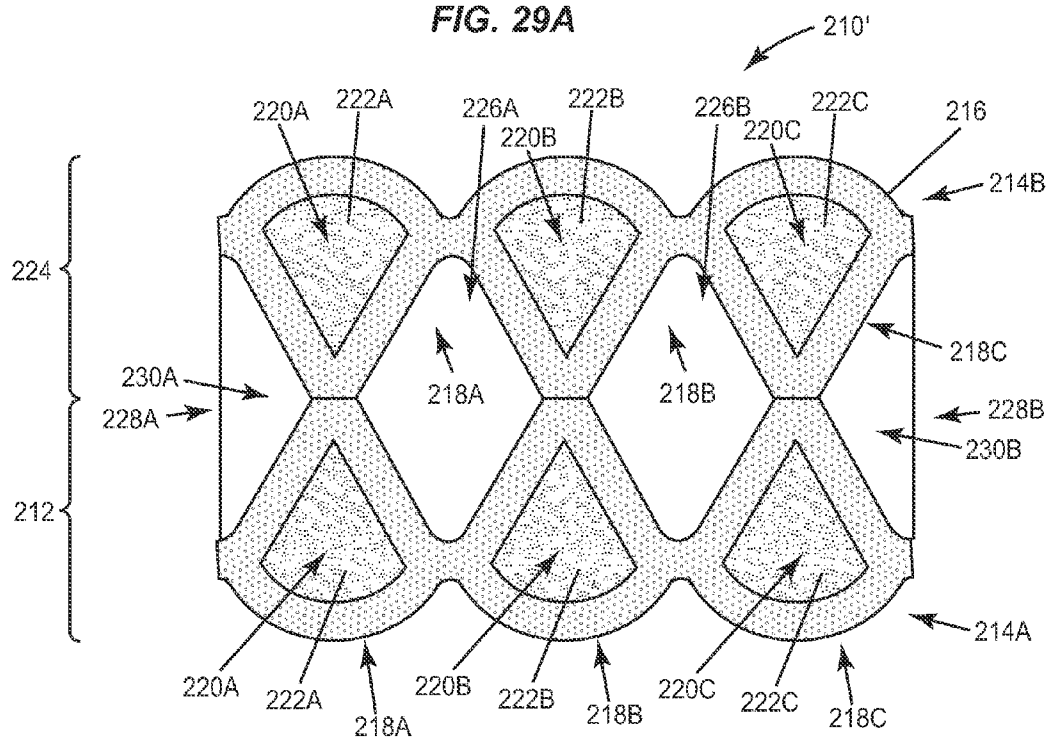


FIG. 29B

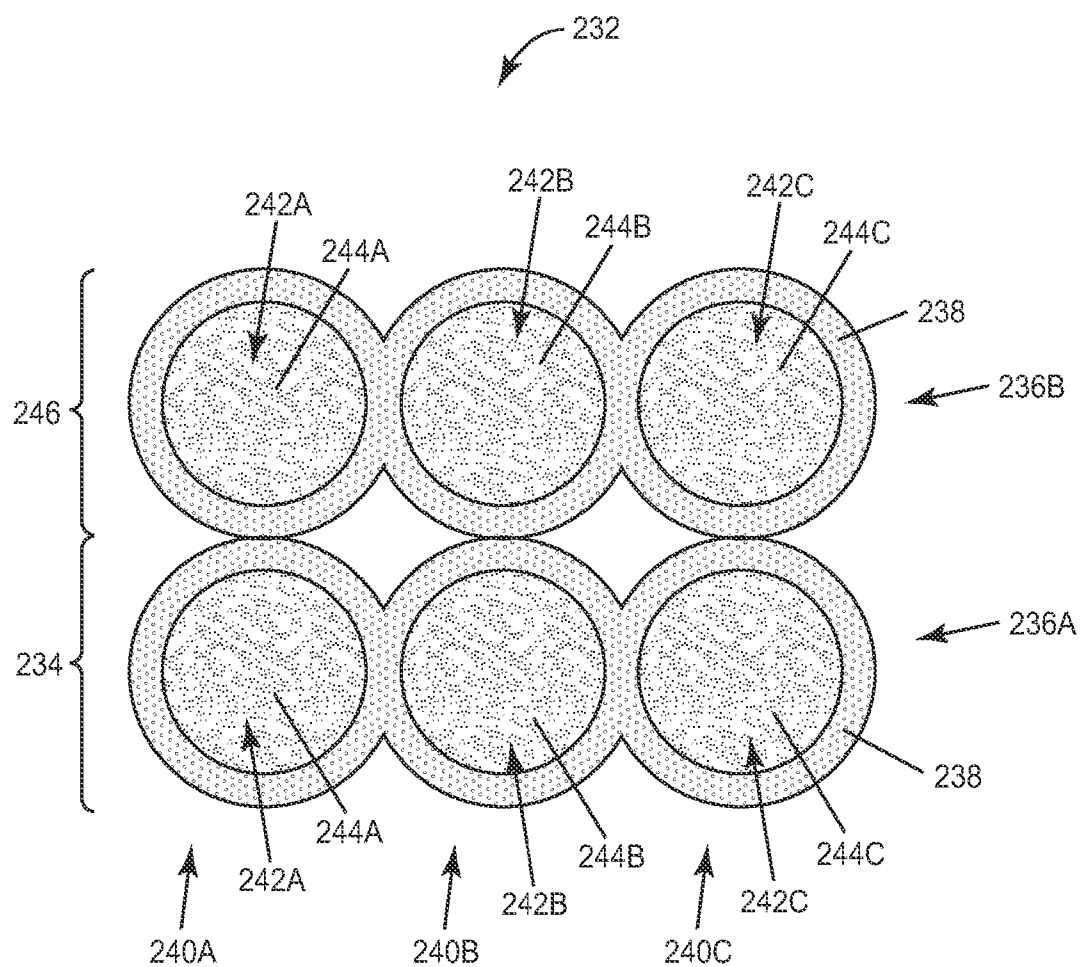


FIG. 30

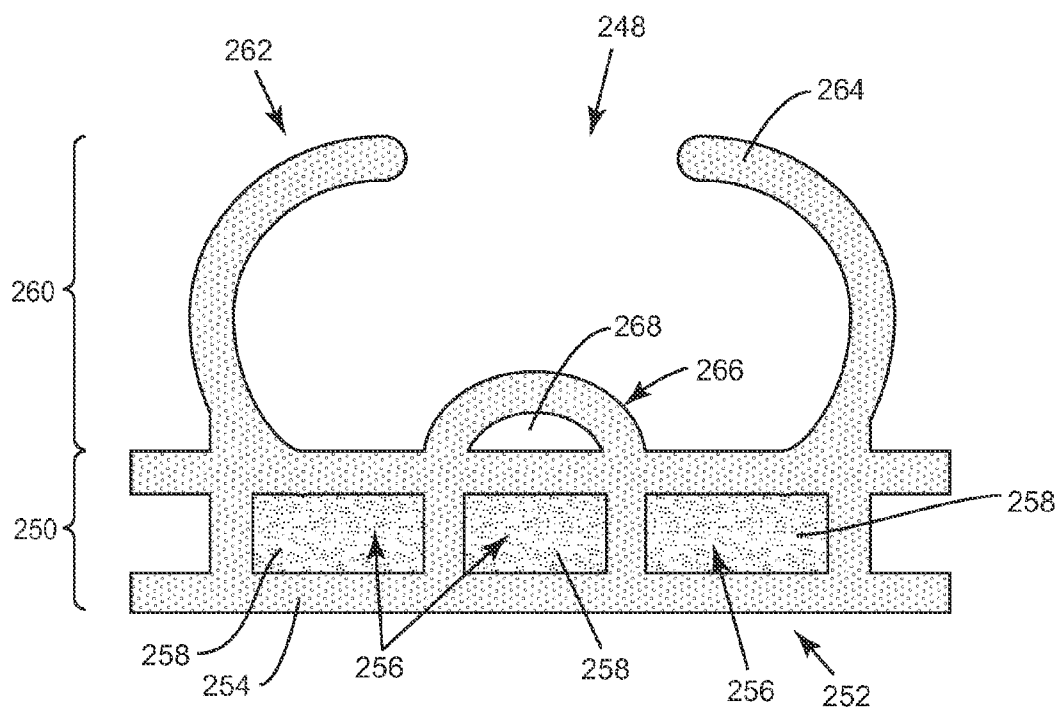


FIG. 31A

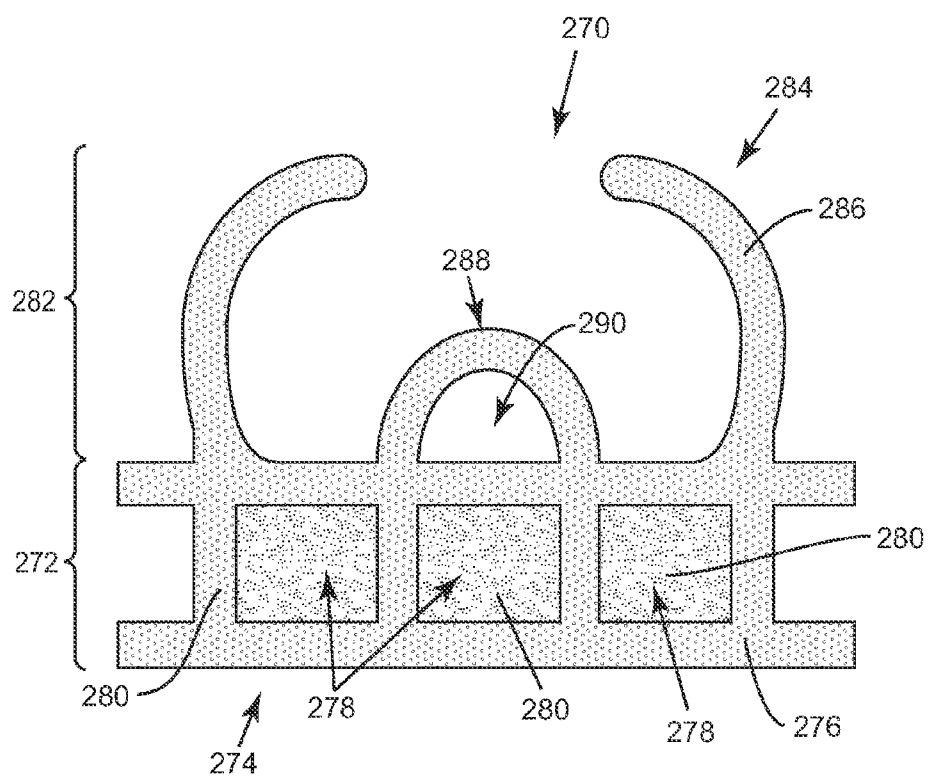


FIG. 31B

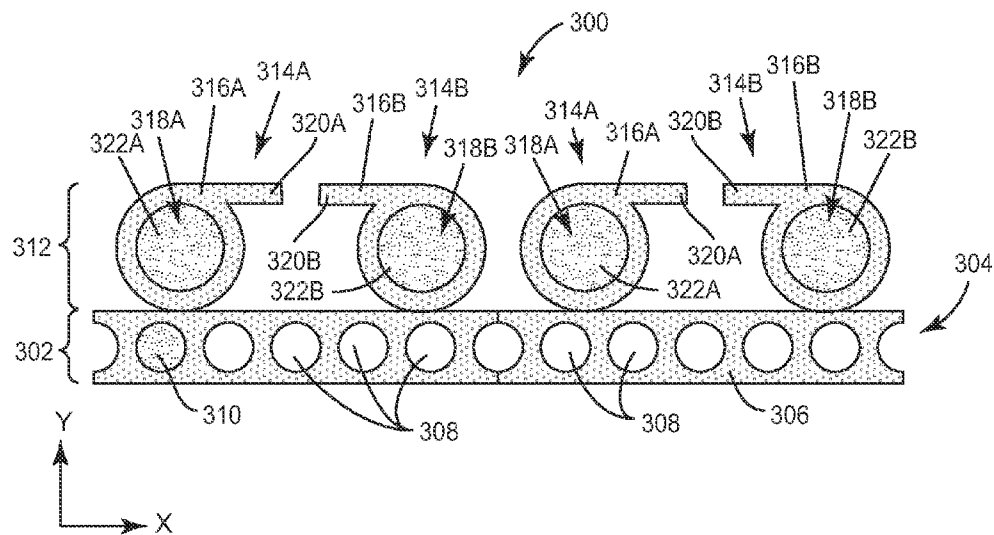


FIG. 32

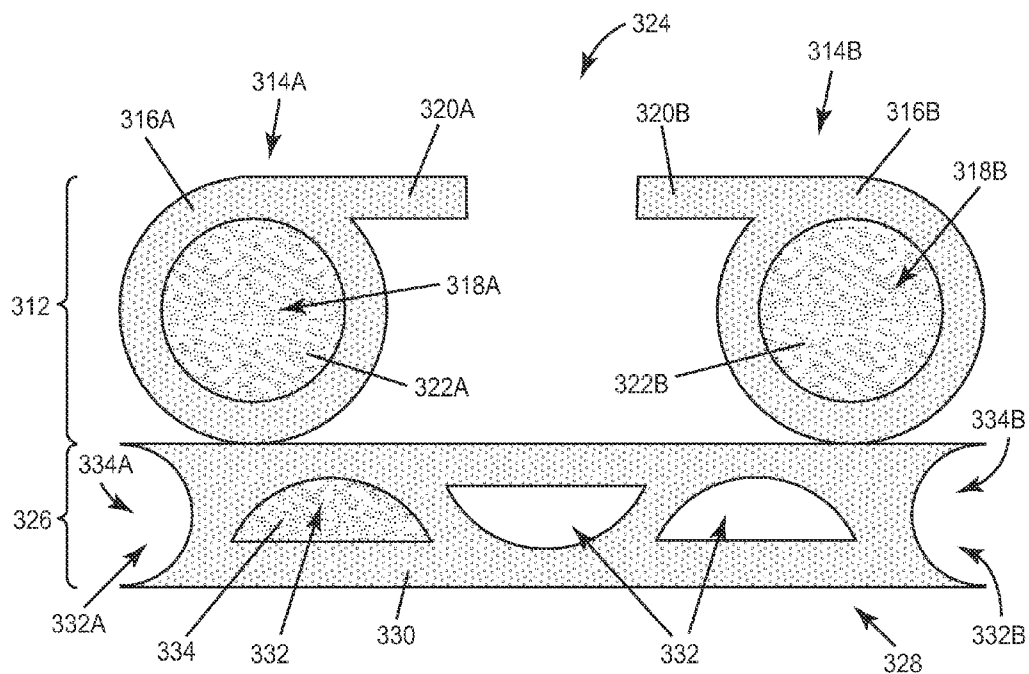


FIG. 33

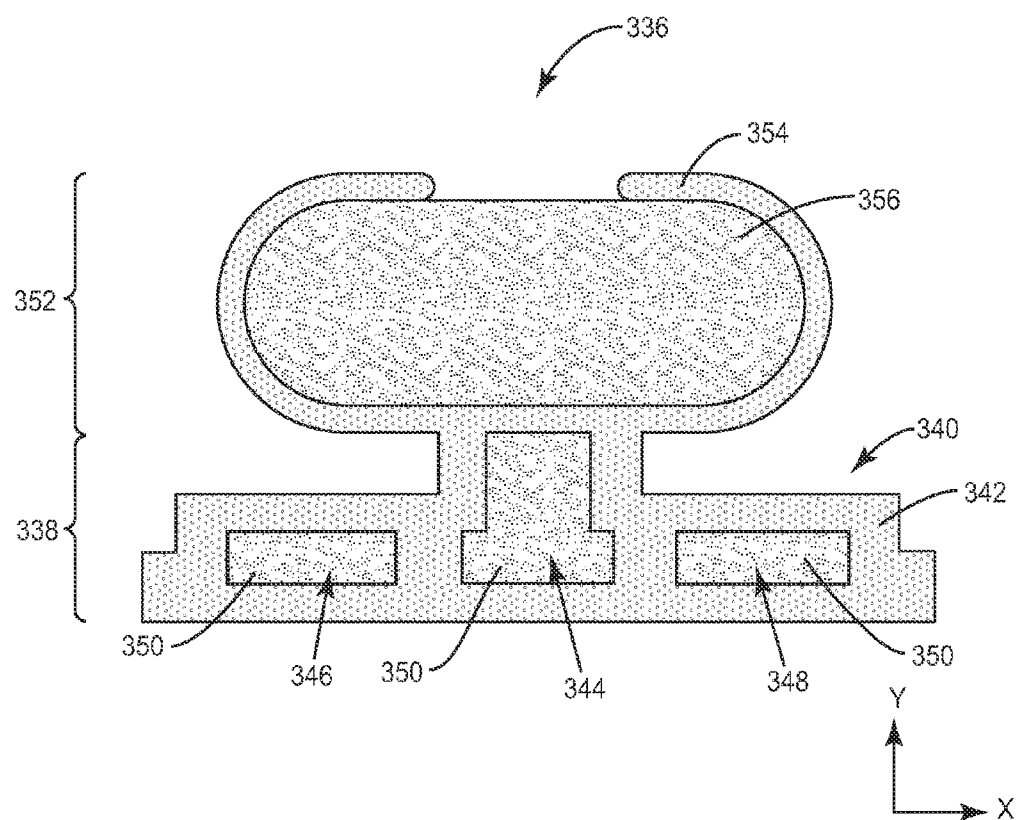


FIG. 34

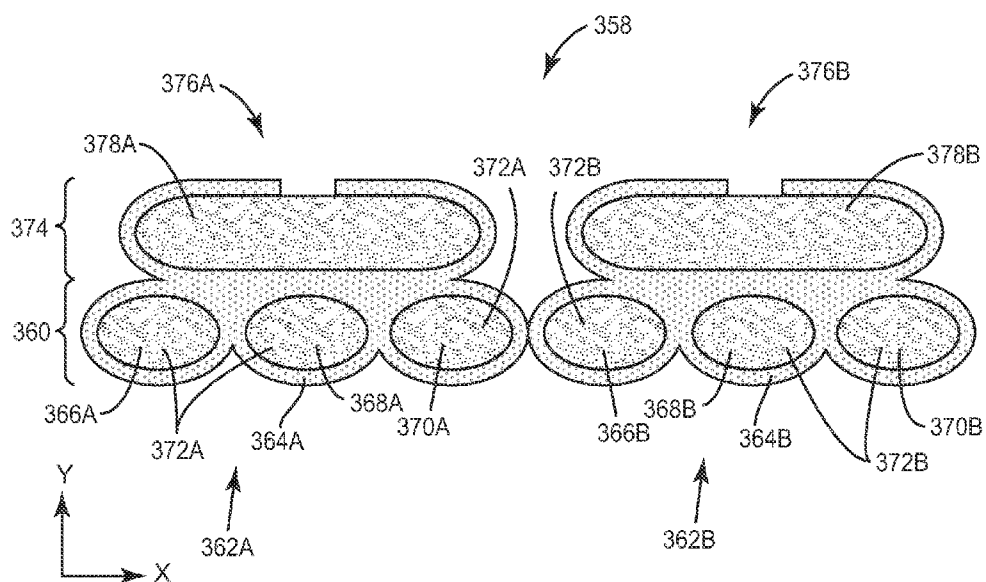


FIG. 35A

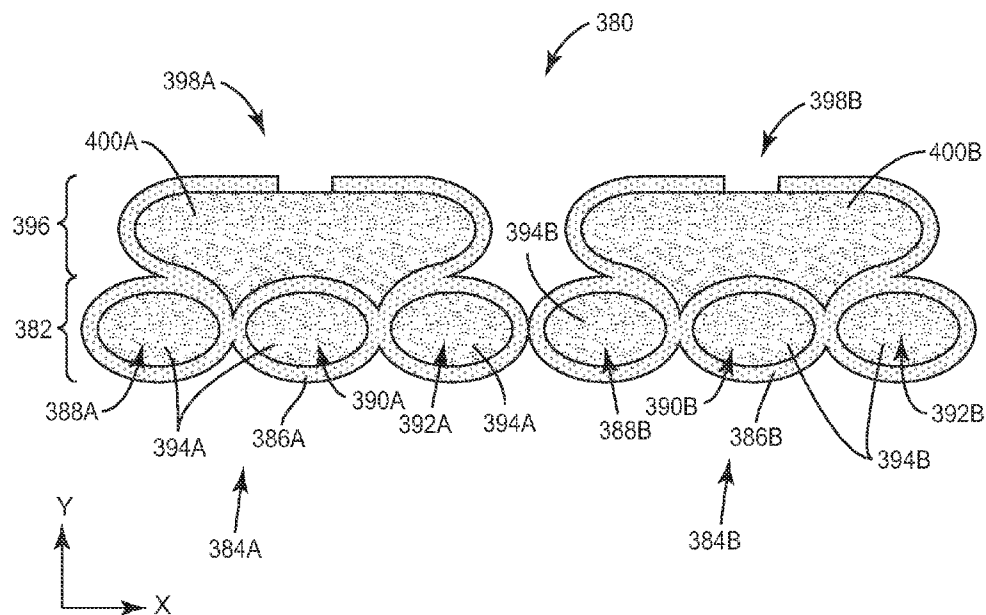


FIG. 35B

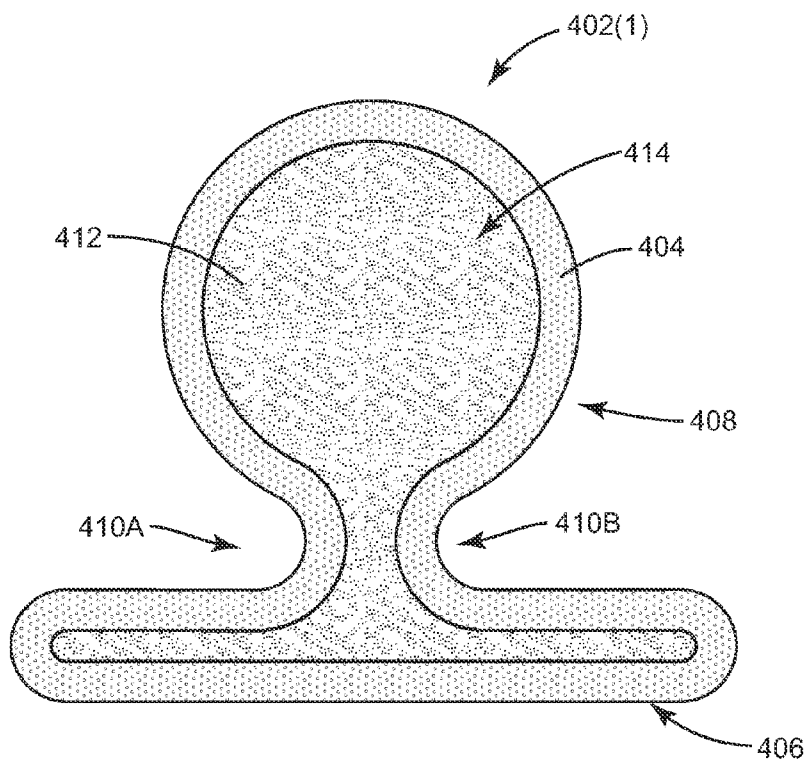


FIG. 36A

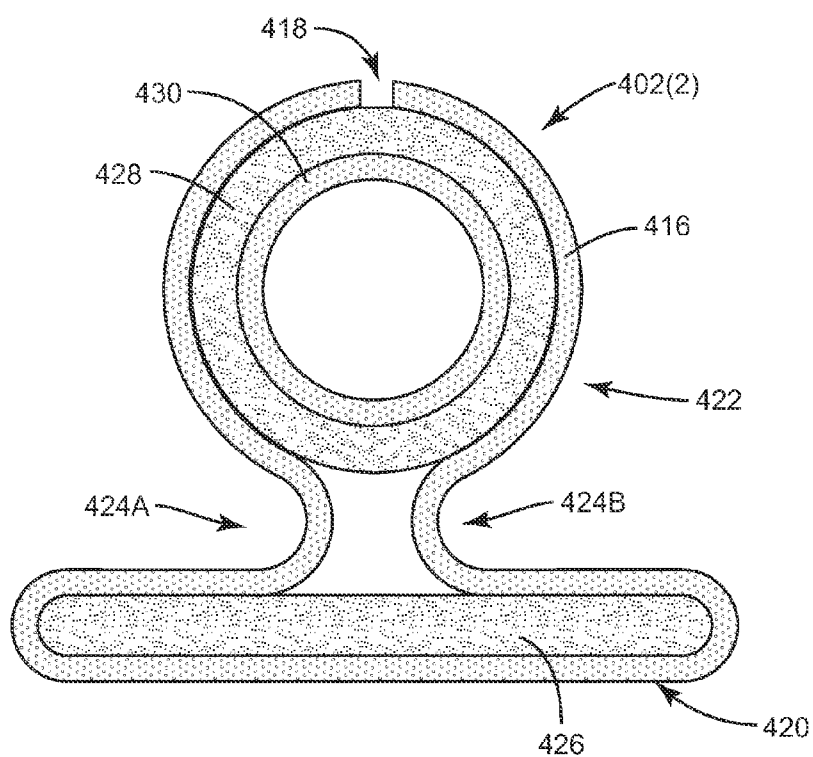


FIG. 36B

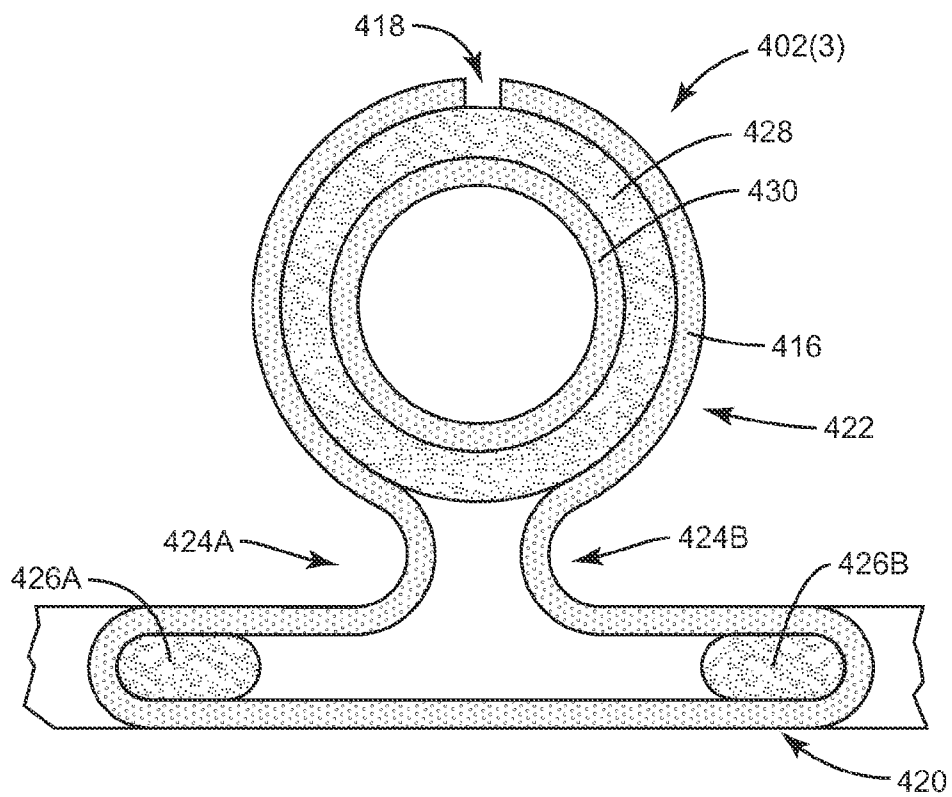


FIG. 36C

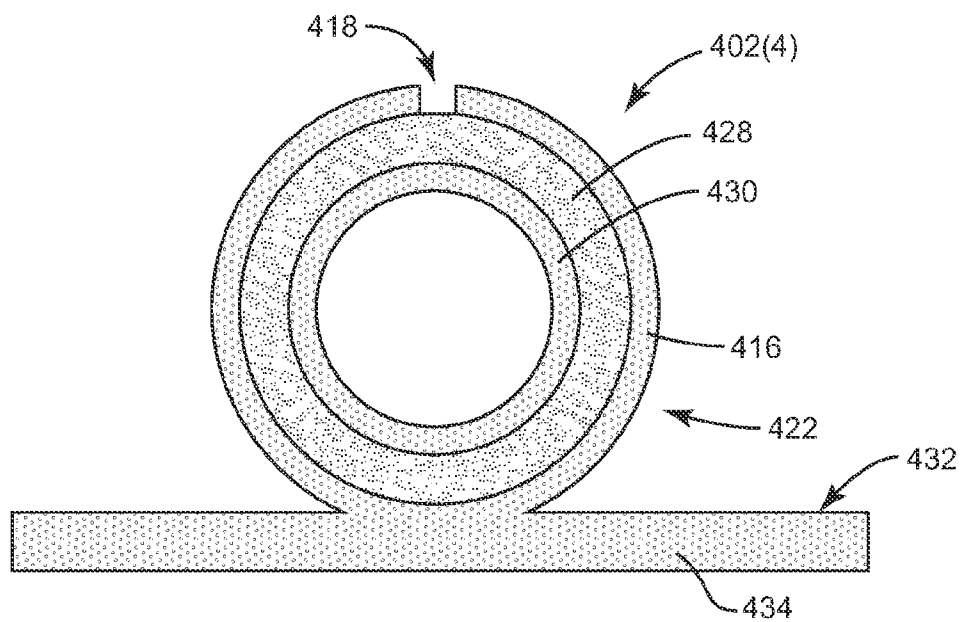


FIG. 36D

ALL-FOAM MATTRESS ASSEMBLIES WITH FOAM ENGINEERED CORES HAVING THERMOPLASTIC AND THERMOSET MATERIALS, AND RELATED ASSEMBLIES AND METHODS

PRIORITY APPLICATION

[0001] The present application claims priority to U.S. Patent Application Ser. No. 61/724,556 filed on Nov. 9, 2012 entitled "All-foam Mattress Assemblies With Foam Engineered Cores Having Thermoplastic and Thermoset Materials, And Related Assemblies And Methods," which is incorporated herein by reference in its entirety.

RELATED APPLICATIONS

[0002] This application is related to U.S. patent application Ser. No. 13/630,435, filed on Sep. 28, 2012, entitled "Cellular Mattress Assemblies and Related Methods," which claims priority to U.S. Provisional Patent Application Ser. No. 61/541,434 filed on Sep. 30, 2011, entitled "Cellular Mattress Assemblies and Related Methods," both of which are incorporated herein by reference in their entireties.

[0003] This application is related to U.S. patent application Ser. No. 13/458,239, filed on Apr. 27, 2012, entitled "Unitary Composite/Hybrid Cushioning Structure(s) And Profile(s) Comprised Of A Thermoplastic Foam(s) And A Thermoset Material(s) and Related Methods," which claims priority to U.S. Provisional Patent Application Ser. No. 61/480,780, filed on Apr. 29, 2011, entitled "Unitary Composite/Hybrid Cushioning Structure(s) And Profile(s) Comprised Of A Thermoplastic Foam(s) And A Thermoset Material(s) and Related Methods," both of which are incorporated herein by reference in their entireties.

[0004] This application is also related to U.S. patent application Ser. No. 12/716,804, filed on Mar. 3, 2010, entitled "Unitary Composite/Hybrid Cushioning Structure(s) and Profile(s) Comprised of A Thermoplastic Foam(s) and A Thermoset Material(s)," which claims priority to U.S. Provisional Patent Application No. 61/157,970, filed on Mar. 6, 2009, entitled "Composite/Hybrid Structures and Formulations of Thermoset Elastomer Foams and Thermoplastic Engineered Geometry Foam Profiles," both of which are incorporated herein by reference in their entireties.

[0005] This application is related to U.S. Design patent application Ser. No. 29/403,050, filed on Sep. 30, 2011, entitled "Edge Support Cushion," which is incorporated herein by reference in its entirety.

BACKGROUND

[0006] 1. Field of the Disclosure

[0007] The field of the disclosure relates generally to cushioning structures. The cushioning structures can be used for any cushion applications desired, including but not limited to mattresses, seats, foot and back support, and upholstery, as non-limiting examples.

[0008] 2. Technical Background

[0009] Cushioning structures are employed in support applications. Cushioning structures can be employed in bedding and seating applications, for example, to provide cushioning and support. Cushioning structures may also be employed in devices for safety applications, such as helmets and automobiles for example.

[0010] Cushioning structures have evolved into relatively-heavy assemblies weighing sometimes considerably more than fifty (50) pounds to provide the required high and low stiffness desired by users. For example, it may be desirable to provide a cushioning material or device in which a body or object will easily sink therein a given distance before the applied weight is supported. As another example, it may be desired to provide surfaces having low stiffness initially during application of weight, while the underlying structure needs to have high stiffness for support.

[0011] A queen-size innerspring mattress may weigh more than sixty-five (65) pounds due to the various components required to deliver the high and low stiffness performance. An example of a cushioning structure employing layers of varying thicknesses and properties for discussion purposes is provided in a mattress **10** of FIG. 1A as is known in the art. As illustrated therein, an innerspring **12** is provided. The innerspring **12** is comprised of a plurality of traditional spring coils **14** arranged in an interconnected matrix to form a flexible core structure and support surfaces of the mattress **10**. The spring coils **14** are also connected to each other through interconnection helical wires **18**. The innerspring **12** is disposed on top of a box spring **22** to provide base support.

[0012] To provide a cushioning structure with high and low stiffness features, various layers of sleeping surface or padding material **26** can be disposed on top of the innerspring **12**. The padding material **26** provides a cushioning structure for a load placed on the mattress **10**. In this regard, the padding material **26** may be made from various types of foam, cloth, fibers and/or steel to provide a generally repeatable comfortable feel to the individual seeking a place to either lie, sit, or rest the body as a whole or portions thereof. To provide the cushioning structure with high and low stiffness features, the padding material **26** may consist of multiple layers of materials that may exhibit different physical properties.

[0013] For example, foam polymer materials, particularly thermoset materials having a relatively heavy density of at least two (2) pounds per cubic foot, can be used as materials of choice for the padding material **26**. The foam polymer materials provide a level of cushion, unlike steel spring structures, or the like. One or more intermediate layers **30** underneath the uppermost layer **28** may be provided to have greater stiffness than the uppermost layer **28** to provide support and pressure spreading that limits the depth to which the body or portions thereof sinks. A bottom layer **32** may be provided below the intermediate layers **30** and uppermost layer **28**. The uppermost layer **28**, the intermediate layers **30**, and the bottom layer **32** serve to provide a combination of desired cushioning characteristics. Upholstery **34** may be placed around the entire padding material **26** and innerspring **12** to provide a fully assembled mattress **10**.

[0014] As mattress technology evolves, all-foam mattresses have been developed in an effort to deliver the stiffness and comfort requirements needed by users. The result is a foam mattress with a weight generally more than a comparable innerspring mattress. For example, a queen-sized all-foam mattress may easily weigh over one-hundred (100) pounds. FIG. 1B depicts a cross-sectional view of a mattress **36** made exclusively with foam and having multiple layers **38(1)-38(5)** having bottom surfaces **40(1)-40(5)** and top surfaces **42(1)-42(5)**, respectively. Each layer may contribute desirable stiffness and comfort performance characteristics at the expense of weight. The bottom surfaces **40(1)-40(5)** and the top surfaces **42(3)-42(5)** may generally be co-planar, but, for

example, top surfaces 42(1), 42(2) may include ribs, bumps, or protrusions 44(1)-44(2) which do not appear to significantly reduce the weight of the mattress 36.

[0015] In manufacturing of a mattress, one person generally can no longer easily lift a mattress. In logistics where the mattress is transported from the manufacturing facility to the user, and in transportation and storage locations within a supply chain, a single logistics person also generally can no longer lift a mattress. It is also becoming more difficult for a homemaker to make a bed given the mattress thickness and heavier weight. Mattresses generally also require rotating and/or flipping the mattress on a regular basis and this is difficult for even two people to accomplish.

[0016] What is needed is a mattress that includes all the performance characteristics and standard dimensions of conventional mattresses yet is easier to transport when changing locations, and handle when making the bed. The mattress should also provide users a practical opportunity to flip and/or rotate the mattress as desired.

SUMMARY OF THE DETAILED DESCRIPTION

[0017] Embodiments disclosed herein include all-foam mattress assemblies with foam engineered cores having thermoplastic and thermoset materials, and related assemblies and methods. All-foam mattress assemblies use foam-based materials, such as thermoplastic and thermoset, to provide cushioning and support characteristics for a user in the sleeping area of a mattress during sleep or rest. The all-foam mattress assemblies may include foam comfort layer(s), foam transitional layer(s), and a foam engineered core. The all-foam engineered core may lessen a density of a mattress assembly by comprising thermoset member(s), and engineered geometric thermoplastic material profile(s) adjacent to the thermoset member(s). The engineered geometric thermoplastic material profile(s) may be disposed in a parallel or substantially parallel arrangement. In this manner, the all-foam engineering core may provide cushioning and support characteristics with reduced density compared to a foam mattress providing similar cushioning and support through solid thermoset layers.

[0018] In this regard, in one embodiment an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may also include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may also include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, bulk-free volume, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer and convey the load to the deck. In this manner, the foam engineering core may be customized to deliver various cushioning characteristics.

[0019] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one

foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer having a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may include the foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may collectively be configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck. Collectively, an unloaded density of the at least one foam comfort layer, the at least one foam transitional layer, and the foam engineered core may comprise a density between 0.8 pounds per cubic foot and 3.0 pounds per cubic foot. In this manner, the mattress assembly may be of a low-density to be more easily transported.

[0020] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may also include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles and a plurality of thermoset members. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may be collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck. The foam engineered core may comprise bulk-free volume. In this manner, the all-foam mattress assembly may be manufactured with a lower density to enable easier maintenance by the user, for example, when rotating and/or flipping the mattress.

[0021] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may include a foam engineered core being less dense than the at least one foam transitional layer. The foam engineered core comprises a plurality of engineered geometric thermoplastic material profiles, bulk-free volume, a deck, and plurality of thermoset members collectively configured with the plurality of engineered geometric thermoplastic material profiles to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck. In this manner, the all-foam mattress assembly may be utilized as part of a mattress that may be more easily maintained by a single user in regards to changing sheets and flipping the mattress.

[0022] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam

comfort layer. The all-foam mattress assembly may also include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may be collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck. The at least one foam transitional layer may comprise between fifteen (15) percent and fifty (50) percent bulk-free volume, and the at least one foam transitional layer is configured to support the load through the at least one foam comfort layer. In this manner, the foam all-mattress assembly may be less dense and thereby more easily transported from the factory to the user.

[0023] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may be collectively configured to receive the load conveyed from the at least one transitional layer and to convey the load to the deck. The foam engineered core may include bulk-free volume. In this manner, a low cost all-foam mattress assembly may be provided.

[0024] In another embodiment, an all-foam mattress assembly is provided. The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, a load allocation member, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may be collectively configured to receive the load conveyed from the at least one foam transitional layer via the load allocation member and to convey the load to the deck. A strain of a combined height of the load allocation member, plurality of engineered geometric thermoplastic material profiles, and the plurality of thermoset members have a stress-strain relationship represented by Y being less than or equal to $0.012143 \cdot X^4 - 0.7467 \cdot X^3 + 10.03761 \cdot X^2 + 346.196 \cdot X - 123.5391$, wherein X being strain measured in percent of the foam engineered core, and Y being a corresponding stress in pascals for values of X between 15 to 42 percent. In this manner, the foam engineered

core may provide the comfort characteristics desired by the user with a lower mattress density.

[0025] The all-foam mattress assembly may include at least one foam comfort layer to receive a load of a user, and the at least one foam comfort layer may include a comfort layer stress-strain relationship. The all-foam mattress assembly may include at least one foam transitional layer receiving the load from the at least one foam comfort layer. The at least one foam transitional layer may have a density more than a density of the at least one foam comfort layer. The all-foam mattress assembly may include a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck. The plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members may be collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck. A stress of the foam engineered core is greater for any given foam transitional layer strain as compared to the foam comfort layer stress-strain relationship and is less as compared to the support layer stress-strain relationship. In this manner, the performance of the all-foam mattress assembly may be customized to provide a desired stress-strain relationship at a lower density and manufacturing cost.

[0026] Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

[0027] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

[0028] FIG. 1A is an exemplary prior art mattress employing an innerspring of wire coils illustrating a mattress that may be difficult to transport, flip, and rotate because of its weight and density;

[0029] FIG. 1B is an exemplary prior art all-foam mattress employing multiple layers of foam illustrating a second example of a mattress that may be difficult to move because of its weight and thickness;

[0030] FIG. 2 is a top perspective view of an exemplary mattress assembly depicted within a mattress to illustrate the all-foam mattress assembly relative to the mattress;

[0031] FIG. 3A is a front side view of the mattress assembly depicted within the mattress of FIG. 2 to illustrate the relative positions of at least one comfort layer, at least one transitional layer, and a foam engineered core comprising a plurality of thermoset members and a plurality of engineered geometric thermoplastic material profiles;

[0032] FIG. 3B is a front side close-up view of a portion of the foam engineered core of FIG. 3A including a load distri-

bution member, one of a plurality of thermoset members, one of a plurality of engineered geometric thermoplastic material profiles having an arch-shape, and one of a plurality of thermoplastic support members to illustrate various components which may convey the load of the user within the foam engineered core;

[0033] FIGS. 4 and 5 are a right side view and a top view, respectively, of the all-foam mattress assembly depicted within the mattress of FIG. 2 to illustrate the all-foam mattress assembly extending across a sleeping area;

[0034] FIGS. 6 and 7 are a front side exploded view and a left side exploded view, respectively, of the all-foam mattress assembly of FIG. 2 to illustrate individual components of the all-foam mattress assembly of FIG. 2;

[0035] FIGS. 8A-8D are front side views, respectively, of other configuration examples of a mattress assembly having various heights illustrating other examples of the all-foam mattress assembly of FIG. 2;

[0036] FIG. 9A is an exemplary cushioning structure comprised of a thermoset material bonded to a thermoplastic material with a stratum;

[0037] FIG. 9B is an exemplary cushioning structure comprised of a thermoset material adjacent to a thermoplastic material without a stratum;

[0038] FIG. 10 is an exemplary chart of performance curves showing strain (i.e., deflection) under a given stress (i.e., pressure) for the thermoplastic material of FIG. 9, thermoset material of FIG. 9, and cushioning structure of FIG. 9 to illustrate their individual and combined support characteristics;

[0039] FIG. 11A is a stress-strain chart for an exemplary mattress made of typical low-density thermoset material, illustrating strain on an x-axis and stress on a y-axis;

[0040] FIG. 11B is a stress-strain chart for a second exemplary mattress which is "too hard," and the stress-strain chart includes strain on an x-axis and stress on a y-axis;

[0041] FIG. 11C is a stress-strain chart for a third exemplary mattress which is initially "too soft" and then "too hard," and the stress-strain chart includes strain on an x-axis and stress on a y-axis;

[0042] FIG. 11D is a stress-strain chart for a fourth exemplary mattress which is initially "slightly harder" than the third embodiment of the mattress of FIG. 8C, and abruptly "bottoms-out," and the stress-strain chart includes strain on an x-axis and stress on a y-axis;

[0043] FIG. 11E is a stress-strain chart for a fifth exemplary mattress which is initially gradually comforting, then supportive without bottoming out, and the stress-strain chart includes strain on an x-axis and stress on a y-axis;

[0044] FIG. 12 provides an exemplary chart of stress-strain performance curves showing strain (deflection) under a given stress (pressure) for different types of thermoplastic foam cushioning structures to show the ability to engineer a cellular thermoplastic foam profile to provide the desired firmness and support characteristics in a cushioning structure;

[0045] FIG. 13 is a stress-strain diagram showing stress-strain performance curves for a first example of a portion of a foam engineered core depicted in FIGS. 14 and 15A, a second example of a portion of a foam engineered core depicted in FIGS. 16 and 17, and a third example of a portion of a foam engineered core depicted in FIGS. 18 and 19 illustrating the stress-strain performance impact of different configurations of thermoset, thermoplastic and bulk-free volume to reduce density of the mattress;

[0046] FIGS. 14 and 15A are a side view of the first example of the portion of the foam engineered core and a top perspective view, respectively, of the first example of the portion of the foam engineered core in an exemplary mattress assembly within a mattress;

[0047] FIG. 15B stress-strain diagram showing a stress-strain performance curve for a the first example of a portion of a foam engineered core depicted in FIGS. 14 and 15A, when the thermoset material is bonded to the thermoplastic material with a stratum and a stress-strain performance curve when there is no stratum illustrating that the stratum makes the first example of a portion of a foam engineered core more stiff;

[0048] FIGS. 16 and 17 are a side view of the second example of the portion of the foam engineered core and a top perspective view, respectively, of the second example of the portion of the foam engineered core in an exemplary mattress assembly within a mattress;

[0049] FIGS. 18 and 19 are a side view of the third example of a portion of a foam engineered core and a top perspective view, respectively, of the third example of the portion of the foam engineered core in an exemplary mattress assembly within a mattress;

[0050] FIG. 20 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating a different exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0051] FIG. 21 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0052] FIG. 22 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0053] FIG. 23 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0054] FIG. 24 is a front side view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0055] FIG. 25 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0056] FIG. 26 is a top perspective view of another exemplary mattress having at least one foam comfort layer, at least one foam transitional layer, and a foam engineered core illustrating another exemplary embodiment of a plurality of thermoset members, a plurality of engineered geometric thermoplastic material profiles, and a plurality of thermoplastic support members;

[0057] FIGS. 27A-27I are top perspective views of alternative cellular thermoplastic foam profiles that may serve as one of a plurality of thermoplastic support members within a foam engineered core, or may be encapsulated or filled with a thermoset material to serve as one of a plurality of engineered geometric thermoplastic material profiles within the foam engineered core;

[0058] FIGS. 28A-28D are a top perspective view and three (3) front side views, respectively, of four (4) related exemplary embodiments of cushion structures that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0059] FIGS. 29A and 29B are front side views, respectively, of two (2) related exemplary embodiments of cushion structures that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core to illustrate in FIG. 29B that ends shown in the cushion structure in FIG. 29A may be closed off to form additional openings;

[0060] FIG. 30 is a front side view of an exemplary embodiment of a cushion structure that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0061] FIGS. 31A and 31B are front side views of two (2) related exemplary embodiments of cushion structures that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0062] FIG. 32 is a front side view of an exemplary embodiment of a cushion structure that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0063] FIG. 33 is a front side view of an exemplary embodiment of a cushion structure that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0064] FIG. 34 is a front side view of an exemplary embodiment of a cushion structure that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core;

[0065] FIGS. 35A and 35B are front side views of two (2) related exemplary embodiments of cushion structures that may be used as one or more of a plurality of engineered geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core; and

[0066] FIGS. 36A-36D are front side views of four (4) related exemplary embodiments of cushion structures that may be used as one or more of a plurality of engineered

geometric thermoplastic material profiles and one or more of a plurality of thermoset members within a foam engineered core.

DETAILED DESCRIPTION

[0067] Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0068] Embodiments disclosed herein include all-foam mattress assemblies with foam engineered cores having thermoplastic and thermoset materials, and related assemblies and methods. All-foam mattress assemblies use foam-based materials, such as thermoplastic and thermoset, to provide cushioning and support characteristics for a user in the sleeping area of a mattress during sleep or rest. The all-foam mattress assemblies may include foam comfort layer(s), foam transitional layer(s), and a foam engineered core. The all-foam engineered core may lessen a density of a mattress assembly by comprising thermoset member(s), and engineered geometric thermoplastic material profile(s) adjacent to the thermoset member(s). The engineered geometric thermoplastic material profile(s) may be disposed in a parallel or substantially parallel arrangement. In this manner, the all-foam engineering core may provide cushioning and support characteristics with reduced density compared to a foam mattress providing similar cushioning and support through solid thermoset layers.

[0069] In this disclosure, an exemplary all-foam mattress assembly of a mattress will be discussed first in detail with reference to FIGS. 3A through 8D to introduce structures and related concepts which may result in a lower density mattress assembly. Next, the fundamentals of the design of all-foam mattress assemblies may be discussed in sequence. Material selection will be discussed in relation to FIGS. 9A through 11E and density reduction efforts in the foam engineered core. Then, different thermoplastic profiles will be discussed in relation to FIG. 12 that may provide the proper stress-strain profile for support and comfort for the user while reducing density of the foam engineered core. Next, the introduction of bulk-free volume in combination will different thermoplastic foam profiles will be discussed in reference to FIGS. 13 through 19 will be discussed in density reduction efforts. Lastly, different embodiments of foam engineered cores with reference to FIGS. 20 through 26 and thermoplastic profiles with reference to FIGS. 27A through 36D may be introduced which may be used within the foam engineered core to reduce density yet provide customized comfort and support to benefit the user.

[0070] In this regard, FIGS. 2-3A and 4-7 depict a perspective view, a front side view, a right-side view, a top view, a front-side exploded view, and a left side exploded view of an exemplary all-foam mattress assembly 50-1 of a mattress 51-1. The all-foam mattress assembly 50-1 may include at least one foam comfort layer 52(1)-52(n), at least one foam transitional layer 54, and a foam engineered core 56. The foam engineered core 56 may comprise a plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) disposed in a parallel or substantially parallel arrangement. A

plurality of thermoset members 60(1)-60(n) may be disposed in the parallel or substantially parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n). The foam engineered core 56 may also include at least one deck 62(1), 62(2). These components of the all-foam mattress assembly 50-1 are now introduced in detail.

[0071] It is noted, to provide clarity in respect to other mattress terminology, that the engineered geometric thermoplastic profiles 58(1)-58(n) in combination with the thermoset members 60(1)-60(p) are an embodiment of a “transition layer.” In addition, the decks 62(1), 62(2) are an embodiment of “at least one support layer.”

[0072] As the all-foam mattress assembly 50-1 in FIG. 2 depicts, the at least one foam comfort layer 52(1)-52(2) may contain two (2) layers; however, there may be only one (1) layer or more than two (2) layers. The foam comfort layers 52(1), 52(2) may receive a load F_w from a user (not shown) and directly or indirectly convey that load F_w to the foam engineered core 56 via the foam transitional layer 54 so that the user may be supported with a comfort characteristic as discussed below. The foam comfort layers 52(1), 52(2) may include conveyance surfaces 64(1), 64(2), respectively, facing the foam transitional layer 54 and configured to directly or indirectly convey the load F_w to the foam transitional layer 54. The conveyance surfaces 64(1), 64(2), of the foam comfort layers 52(1), 52(2), respectively, may be planar to more uniformly convey the load F_w to the foam transitional layer 54 and to reduce manufacturing cost.

[0073] The foam comfort layers 52(1), 52(2) may be in closer proximity to the user as compared to the foam transitional layer 54 and the foam engineered core 56. Accordingly, the foam comfort layers 52(1), 52(2) may include thermoset material, for example, viscoelastic foam to provide a soft comfortable surface near the user that may be configured to provide minimal resistance and readily deflect to conform to a shape of the user's body contacting the mattress 51-1. The foam comfort layers 52(1), 52(2) may be soft consistent with an impression load deflection (ILD) rating of eight (8) to twenty (20). ILD is a measurement of foam firmness. Firmness is independent of foam density; although it is frequently believed that higher density foams are firmer, it is possible to have high density foams that are soft—or low density foams that are firm, depending on the ILD specification. ILD specification relates to comfort. It is a measurement of the surface feel of the foam. ILD may be measured by indenting, or in other words compressing, a foam sample twenty-five (25) percent of its original height. The amount of force required to indent the foam is its twenty-five (25) percent ILD measurement. The more force required, the firmer the foam. Flexible foam ILD measurements can range from ten (10) pounds (supersoft) to about eighty (80) pounds (very firm).

[0074] The mattress 51-1 may include upholstery (not shown) comprising, for example, fabric disposed between the user and the foam comfort layers 52(1), 52(2) for texture, heat dissipation, or hygienic reasons. The upholstery may be hidden from view but may form an outer surface of the mattress 51-1.

[0075] With continuing reference to FIGS. 2-3A and 4-7, the foam transitional layer 54 may be disposed between the foam comfort layers 52(1)-52(2) and the foam engineered core 56. The foam transitional layer 54 may receive the load F_w from the foam comfort layers 52(1)-52(2), and subsequently convey the load F_w to the foam engineered core 56.

The foam transitional layer 54 may also comprise thermoset to provide softness and comfort to the user. However, the foam transitional layer 54 may be rated between fifteen (15) and forty (40) ILD to provide more gradually more support to the user than may be offered by the foam comfort layers 52(1)-52(2). The higher ILD rating may result because the thermoset of the foam transitional layer 54 may have a higher density than the foam comfort layers 52(1)-52(2). In this manner, the foam transitional layer 54 may prevent rotating and/or flipping the mattress rotating and/or flipping the mattress the all-foam mattress assembly 50-1 from deflecting as much under the load F_w .

[0076] The foam transitional layer 54 may include a load receiving surface 66 to receive the load F_w directly or indirectly from the foam comfort layers 52(1)-52(2). The load receiving surface 66 may face the user and may also be planar or substantially planar-shaped to allow horizontal movement between the foam transitional layer 54 and the foam comfort layers 52(1)-52(2). The load F_w receiving surface 66A of the foam transitional layer 54 may communicate with the conveyance surfaces 64(1), 64(2) of the foam comfort layers 52(1)-52(2). In this manner, there may be less motion transfer throughout the mattress 51-1 as the foam transitional layer 54 may be more isolated from disturbance forces directed orthogonal to the load F_w . It is also noted that the motion isolation may be enhanced by placing thin substances (not shown) with high surface lubricity, for example, silicone, between the foam transitional layer 54 and the foam comfort layers 52(1)-52(2).

[0077] It is noted that the mattress 51-1 includes optional side supports 55 and optional side support cushions 57 which may be disposed around a perimeter of the foam engineered core 56. The optional side supports 55 and optional side support cushions 57 may be configured to provide additional strength around a perimeter of the mattress 51-1 as the user mounts and dismounts from the mattress 51-1. The optional side supports 55 and optional side support cushions 57 may be covered by either the foam comfort layers 52(1)-52(2) and/or the foam transitional layer 54 as depicted in FIG. 2. The optional side supports 55 and optional side support cushions 57 are outside a sleeping area 53 of the mattress 51-1 and thereby considered outside of the all-foam mattress assembly 50-1. The sleeping area 53 of the mattress 51-1 may be configured to receive the load F_w of the user when not mounting or dismounting the mattress 51-1.

[0078] Next, the foam engineered core 56 may provide additional support to the all-foam mattress assembly 50-1, yet provide a comfort contribution to deliver gradually increased resistance to the load F_w while decreasing the overall density of the all-foam mattress assembly 50-1. The foam engineered core 56 may include the engineered geometric thermoplastic material profiles 58(1)-58(n), disposed in a parallel arrangement as discussed above. In this way, the engineered geometric thermoplastic material profiles 58(1)-58(n) may support the foam transitional layer 54 across the all-foam mattress assembly 50-1.

[0079] The foam engineered core 56 may also include a load distribution member 68 configured to receive the load F_w conveyed by the foam transitional layer 54 and more uniformly distribute the load F_w across multiple ones of the engineered geometric thermoplastic material profiles 58(1)-58(n). In this manner, the user may perceive the engineered geometric thermoplastic material profiles 58(1)-58(n) less and instead sense a more uniform sleeping environment free

of pronounced “bumps,” which may facilitate a more comfortable sleeping experience for the user. The load distribution member 68 may comprise, for example, thermoplastic for relative rigidity and strength. The load distribution member 68 may also preferably include a low density composition, for example, less than 1.6 pounds per cubic foot to reduce the density of the all-foam mattress assembly 50-1.

[0080] The load distribution member 68 may include a first surface 70A and a second surface 70B. The first surface 70A may also be planar or substantially planar-shaped to allow the foam transitional layer 54 to move in a horizontal plane P_G (FIG. 3A) with respect to the load distribution member 68 of the foam engineered core 56. The second surface 66B of the foam transitional layer 54 may communicate with the first surface 70A of the load distribution member 68. In this manner, there may be less motion transfer throughout the mattress 51-1 as the foam engineered core 56 may be more isolated from disturbance forces directed orthogonal to the load F_w . It is also noted that the motion isolation may be enhanced by placing thin substances (not shown) with high surface lubricity, for example, silicone, between the second surface 66B of the foam transitional layer 54 and the first surface 70A of the load distribution member 68.

[0081] With continued reference to FIGS. 2-3A and 4-7, the foam engineered core 56 may also include the thermoset members 60(1)-60(n) as discussed above. The engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n) may be configured to collectively receive the load F_w from the load distribution member 68. The term “collectively” in this disclosure refers to sharing the burden of the load F_w , so that the load F_w may be distributed among multiple members in a parallel relationship instead of a serial relationship. In this manner, performance characteristics of the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) and the plurality of thermoset members 60(1)-60(n) may be jointly contributed.

[0082] Within the foam engineered core 56, the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) may be spaced apart a distance D_{SB} (FIG. 3A) and bulk-free volume 76 (FIG. 3A) may be disposed between. As the distance D_{SB} may be increased, a density of the all-foam mattress assembly 50-1 may be decreased, as volume between the engineered geometric thermoplastic material profiles 58(1)-58(n) may be purposefully occupied by less dense structures or bulk-free volume 76 disposed within the distance D_{SB} . For example, the foam engineered core 56 may further include a plurality of thermoplastic support members 72(1)-72(p) arranged in the parallel arrangement and disposed between the engineered geometric thermoplastic material profiles 58(1)-58(n) and thermoset members 60(1)-60(n). The thermoplastic support members 72(1)-72(p) may be made of low-density foam, for example, polyethylene with a density of 1.6 pounds per cubic foot or less to facilitate weight savings. In addition, the thermoplastic support members 72(1)-72(p) may include one or more first spring bore 74A(1)-74A(p) and/or one or more second spring bore 74B(1)-74B(p) which may be occupied by bulk-free volume 76. The first spring bores 74A(1)-74A(p) and/or second spring bores 74B(1)-74B(p) may extend through the thermoplastic support members 72(1)-72(p) to provide a performance contribution across the first spring bores 74A(1)-74A(p) and/or second spring bores 74B(1)-74B(p). In addition, the first

spring bores 74A(1)-74A(p) and/or second spring bores 74B(1)-74B(p) may be configured to gradually close when subjected to the load F_w .

[0083] The volume between the plurality of thermoplastic support members 72(1)-72(p) and the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) may also be occupied by the bulk free volume 76 and reduce the density of the all-foam mattress assembly 50-1. The bulk-free volume 76 may reduce the density of the all-foam mattress assembly 50-1 because the bulk-free volume 76 is free of solid mass. The bulk-free volume 76 may be air or a low-pressure vacuum environment. Further, the bulk-free volume 76 is separate from air bubbles disposed within the plurality of closed cells which may be contained within either thermoplastic or thermoset material. The thermoplastic support members 72(1)-72(p), as well as the engineered geometric thermoplastic material profiles 58(1)-58(n), and the plurality of thermoset members 60(1)-60(n) may be collectively configured to receive the load F_w conveyed from the foam transitional layer 54 and convey the load F_w to the decks 62(1), 62(2).

[0084] The thermoplastic support members 72(1)-72(p) may also include a plurality of first grooves 78A(1)-78A(p) (FIG. 3A) and a plurality of second grooves 78B(1)-78B(p) (FIG. 6) opposite the first grooves 78A(1)-78A(p). The first grooves 78A(1)-78A(p) and the second grooves 78B(1)-78B(p) may be configured to gradually close when the thermoplastic support members 72(1)-72(p) may be subjected to the load F_w . In this manner, the thermoplastic support members 72(1)-72(p) may more easily compress under the load F_w and contribute comparatively less resistance to the load F_w than the engineered geometric thermoplastic material profiles 58(1)-58(n).

[0085] The engineered geometric thermoplastic material profiles 58(1)-58(n) and/or the thermoplastic support members 72(1)-72(p) may be secured to the load distribution member 68. For example, they may be secured using a thermal bond, a cohesive, an adhesive, and/or may be formed together as part of a molding process or extrusion process. In this manner, the engineered geometric thermoplastic material profiles 58(1)-58(n) and/or the thermoplastic support members 72(1)-72(p) may remain in the parallel arrangement even after repeated cycles of being burdened with the load F_w .

[0086] FIG. 3B comprises a close-up of the thermoset member 60(n), the thermoplastic support member 72(p), and the engineered geometric thermoplastic material profile 58(n), but the details also may apply to the thermoset members 60(1)-60(n-1), the thermoplastic support members 72(1)-72(p-1), and the engineered geometric thermoplastic material profiles 58(1)-58(n-1). With reference to FIG. 3B, the thermoset members 60(1)-60(n) may be adjacent to the engineered geometric thermoplastic material profiles 58(1)-58(n) which may comprise a plurality of hollow circular profiles 80(1)-80(n) which may have, for example, an arch-shape. Each of the engineered geometric thermoplastic material profiles 58(1)-58(n) may be secured to and protrude from the load distribution member 68. The hollow circular profiles 80(1)-80(n) include a plurality of inner thermoplastic surfaces 82(1)-82(n) forming a plurality of hollow passageways 84(1)-84(n) and a plurality of outer thermoplastic surfaces 86(1)-86(n) surrounding at least one of the thermoset members 60(n). Each of the thermoset members 60(1)-60(n) may also abut against and/or be secured to complementary ones of the engineered geometric thermoplastic material profiles

58(1)-58(n) with an adhesive, a cohesive, or a thermal bond. In this manner, the movement of the thermoset members **60(1)-60(n)** and the engineered geometric thermoplastic material profiles **58(1)-58(n)** may be linked while directly or indirectly conveying the load F_w to the decks **62(1)**, **62(2)** to provide a customizable stress-strain relationship as discussed below in a later section of this disclosure.

[0087] Next, the decks **62(1)**, **62(2)** of the foam engineered core **56** may include first surfaces **88A(1)**, **88A(2)** and second surfaces **88B(1)**, **88B(2)** which respectively may planar to isolate motion orthogonal to the load F_w . The decks **62(1)**, **62(2)** may comprise a strong lightweight thermoplastic, for example, polyethylene. The decks **62(1)**, **62(2)** may be relatively stiff to provide a structural foundation for the all-foam mattress assembly **50-1**. It is also noted that at least one of the second surfaces **88B(1)**, **88B(2)** may be supported by a rigid structure, for example, a bed frame, for safety reasons.

[0088] FIGS. **8A-8D** depict front views of other examples of the all-foam mattress assembly **50-1** which may be optimized for heights H_2 - H_5 and performance and the details of the differences with mattress assembly **10-1** will now be discussed. FIG. **8A** depicts a front view of an exemplary all-foam mattress assembly **50-2** of a mattress **51-2**. The all-foam mattress assembly **50-2** may comprise two (2) of the foam comfort layers **52(1)** and **52(2)** contributing two (2) inches of height A_2 ; three (3) of the foam transitional layers **54(1)-54(3)** contributing three (3) inches of height B_2 ; and a foam engineered core **56** contributing five and one-half (5.5) inches of height C_2 . A cover pad and/or upholstery **90** may contribute another one-half inch of height D_2 . In this manner, the mattress **51-2** of a height H_2 of eleven (11) inches may be created.

[0089] FIG. **8B** depicts a front view of an exemplary all-foam mattress assembly **50-3** of a mattress **51-3**. The all-foam mattress assembly **50-3** may comprise one (1) foam comfort layer **52(1)** contributing two (2) inches of height A_3 ; three (3) of the foam transitional layers **54(1)-54(3)** contributing three (3) inches of height B_3 ; and a foam engineered core **56** contributing six and one-half (6.5) inches of height C_3 . A cover pad and/or upholstery **90** may contribute another one-half inch of height D_3 . In this manner, the mattress **51-3** of a height H_3 of twelve (12) inches may be created.

[0090] FIG. **8C** depicts a front view of an exemplary all-foam mattress assembly **50-4** of a mattress **51-4**. The all-foam mattress assembly **50-4** may comprise two (2) of the foam comfort layers **52(1)**, **52(2)** contributing three (3) inches of height A_4 ; two (2) of the foam transitional layers **54(1)**, **54(2)** contributing two (2) inches of height B_4 ; and a foam engineered core **56** contributing seven and one-half (7.5) inches of height C_4 . A cover pad and/or upholstery **90** may contribute another one-half inch of height D_4 . In this manner, the mattress **51-4** of a height H_4 of thirteen (13) inches may be created.

[0091] FIG. **8D** depicts a front view of an exemplary all-foam mattress assembly **50-5** of a mattress **51-5**. The all-foam mattress assembly **50-5** may comprise two (2) of the foam comfort layers **52(1)**, **52(2)** contributing four (4) inches of height A_5 ; two (2) of the foam transitional layers **54(1)**, **54(2)** contributing two (2) inches of height B_5 ; and a foam engineered core **56** contributing seven and one-half (7.5) inches of height C_5 . A cover pad and/or upholstery **90** may contribute another one-half inch of height D_5 . In this manner, the mattress **51-5** of a height H_5 of fourteen (14) inches may be created.

[0092] Now that the details of the all-foam mattress assembly **50-1** of a mattress **51-1** have been introduced, details of materials used in the foam engineered core **56** and related embodiments are now discussed in more detail. The fundamental performance and density of the foam engineered core **56** of the all-foam mattress assembly **50** originates from foam materials comprising thermoplastic and thermoset. FIG. **9A** is an exemplary cushioning structure **100** as a hybrid comprised of a thermoset sample material **102** adjacent to a thermoplastic sample material **104**, which both may be found in the foam engineered core **56** of the all-foam mattress assembly **50**. Materials may significantly change the performance of the all-foam mattress assembly **50** in response to the weight F_w of the user and also have a significant impact on the overall density of the all-foam mattress assembly **50**.

[0093] The thermoplastic material **104** and the thermoset material **102** may be cohesively or adhesively bonded together to provide the cushioning structure **100**, or may merely be adjacent to one another. The cushioning structure **100** may also be bonded together with a stratum **101** as shown in FIG. **9**. The stratum **101** may be formed where an outer surface **103A** of the thermoset material **102** contacts or rests against an inner surface **103B** of the thermoplastic material **104**, cohesively or adhesively bonding the inner surface **103B** to the outer surface **103A** in the presence of a coupling agent **105**, for example, an amino-silane such as N-(2-aminoethyl)-3-aminopropyltrimethoxysilane similar to Product SIA0591.0 made by Gelest, Incorporated of Morrisville, Pa., USA. The coupling agent **105** may substantially remain part of the cushioning structure **100** after the stratum **101** may be formed. In this regard, the cushioning structure **100** exhibits a combination of characteristics of the support characteristics of the thermoplastic material **104** and the resiliency and cushioning characteristics of the thermoset material **102**. The thermoplastic material **104** is provided to provide support characteristics desired for the cushioning structure **100**. The thermoplastic material **104** could be selected to provide a high degree of stiffness to provide structural support for the cushioning structure **100**. The thermoset material **102** can provide resiliency and softer cushioning characteristics to the cushioning structure **100**.

[0094] With continued reference to FIG. **9A**, a relative density ρ_1 of the thermoplastic material **104** as compared to a density ρ_2 of the thermoset material **102** can control the responsiveness of the combined cushioning properties, and can also control the weight of the cushioning structure **100**. For example, the density ρ_1 of the thermoplastic material **104** could be in the range between a half (0.5) to thirty (30) pound per cubic foot (or eight (8) to four-hundred eighty (480) kilograms per cubic meter), as an example. However, the density ρ_1 of the thermoplastic material **104** is preferably one and one-half (1.5) pound per cubic foot. The density ρ_2 of the thermoset material **102** may be between one (1) to fifteen (15) pounds per cubic foot (or sixteen (16) to two-hundred forty (240) kilograms per cubic meter), as an example. However, the density ρ_2 of the thermoset material **102** is preferably from 1.8 to 2.5 pound per cubic foot. The weight of the cushioning structure **100** may be reduced by the replacement of the thermoset material **102** with the thermoplastic material **104** because the preferable density ρ_1 of the thermoplastic material **104** may be less than the preferable density ρ_2 of the thermoset material **102**.

[0095] Non-limiting examples of thermoset materials that can be used to provide the thermoset material **102** in the

cushioning structure **100** include polyurethanes, natural and synthetic rubbers, such as latex, silicones, ethylene propylene diene Monomer (M-class) (EPDM) rubber, isoprene, chloroprene, neoprene, melamine-formaldehyde, and polyester, and derivatives thereof. The density ρ_2 of the thermoset material **102** may be provided to any density desired to provide the desired resiliency and cushioning characteristics to the cushioning structure **100**, and can be soft or firm depending on formulations and density. The thermoset material **102** could also be foamed. Further, if the thermoset material **102** selected is a natural material, such as latex for example, it may be considered biodegradable. Further, bacteria, mildew, and mold cannot live in certain thermoset foams. Also note that although the cushioning structure **100** illustrated in FIG. 9 is comprised of at least two materials, the thermoplastic material **104** and the thermoset material **102**, more than two different types of thermoplastic and/or thermoset materials may be provided in the cushioning structure **100**.

[0096] Non-limiting examples of thermoplastic materials that can be used to provide the thermoplastic material **104** in the cushioning structure **100** include polypropylene, polypropylene copolymers, polystyrene, polyethylenes, ethylene vinyl acetates (EVAs), polyolefins, including metallocene catalyzed low density polyethylene, thermoplastic olefins (TPOs), thermoplastic polyester, thermoplastic vulcanizates (TPVs), polyvinyl chlorides (PVCs), chlorinated polyethylene, styrene block copolymers, ethylene methyl acrylates (EMAs), ethylene butyl acrylates (EBAs), and the like, and derivatives thereof. The density ρ_1 of the thermoplastic material **104** may be provided to any density desired to provide the desired weight and support characteristics for the cushioning structure **100**. Further, the thermoplastic material **104** may be selected to also be inherently resistant to microbes and bacteria, making the thermoplastic material **104** desirable for use in cushioning structures and related applications. The thermoplastic material **104** can also be made biodegradable and fire retardant through the use of additive master batches.

[0097] It may be desired to control the combined cushioning properties of the cushioning structure **100** in FIG. 9B. For example, it may be desired to control the degree of support or firmness provided by the thermoplastic material **104** as compared to the resiliency and cushioning characteristics of the thermoset material **102**. In this regard, as an example, the thermoplastic material **104** is provided as a solid block of height E_1 , as illustrated in FIG. 9B. The thermoset material **102** is provided of height E_2 , as also illustrated in FIG. 9B. The relative volume of the thermoplastic material **104** as compared to the thermoset material **102** can control the combined cushioning properties, namely the combined support characteristics and the resiliency and cushioning characteristics, in response to the load F_H of the user. These combined characteristics can also be represented as a unitary strain or deflection for a given stress or pressure, as previously discussed.

[0098] Further, by controlling the volume of the thermoplastic material **104** and the thermoset material **102**, the same combined cushioning properties may be able to be provided in a smaller overall volume or area. For example, with reference to FIG. 9B, the individual heights E_1 and E_2 may be less important in providing the combined cushioning characteristics of the cushioning structure **100** than the ratio of the respective heights E_1 and E_2 . Thus, the overall height E_3 (i.e.,

E_1 together with E_2) of the cushioning structure **100** may be reduced by providing distinct, non-bonded layers of cushioning structures.

[0099] Further, the thermoplastic material **104** and thermoset material **102** may each have different indentation load deflections (ILDs). The thermoplastic material **104** of the cushioning structure **100** can be provided as a cellular thermoplastic foam profile, if desired. By providing the thermoplastic material **104** of the cushioning structure **100** as a cellular foam profile, control of the shape and geometry of the cushioning structure **100** can be provided, as desired. For example, the extrusion foaming art, with the ability to continuously produce and utilize specific die configurations having the ability to geometrically design and profile elements for cushioning support, is a method to obtain the desired thermoplastic engineered geometry foam profiles to be used with a thermoset material or materials to provide the cushioning structure **100**. In this manner, the cushioning structure **100** can be provided for different applications based on the desired geometric requirements of the cushioning structure. Machine direction (MD) attributes as well as transverse direction (TD) attributes may be employed to extrude a thermoplastic foam profile. However, other methods of providing thermoplastic foam profiles may also be employed, including molding, casting, thermal forming, and other processes known to those skilled in the art.

[0100] Thermoset foam profiles can be obtained in emulsified form and are frothed to introduce air into the emulsion to reduce density, and are then cured (vulcanized) to remove additional waters and volatiles as well as to set the material to its final configuration. The cost of thermoset materials can be further reduced through the addition of fillers such as ground foam reclaim materials, nano clays, carbon nano tubes, calcium carbonate, fly ash, and the like, as well as core dust, as this material can provide for increased stability to reduce the overall density and weight of the thermoset material. Further, thermoplastic foams, when used in combination with a thermoset foam, will occupy volume within a cushion structure, thereby displacing the heavier-weight, more expensive thermoset materials, such as latex rubber foam, as an example.

[0101] In this regard, embodiments disclosed herein allow a cushioning structure to be provided in a customized, engineered profile by providing a customized, engineered thermoplastic foam profile. A thermoset material is provided in the engineered thermoplastic foam profile to provide the cushioning structure. In this manner, the shape and resulting characteristics of the cushioning structure can be designed and customized to provide the desired combination of resiliency and cushioning, and support characteristics for any application desired.

[0102] FIG. 9B is a side view of the thermoplastic material **104** and the thermoset material **102** of FIG. 9A wherein the thermoplastic material **104** and the thermoset material **102** are adjacent to each other but not secured to each other with a stratum **101**. In this manner, the thermoplastic material **104** and the thermoset material **102** may be less restricted to move with respect to each other. In this manner, forces (not shown) angled non-orthogonal to the outer surface **103A** and inner surface **103B** may be better prevented from being transferred between the outer surface **103A** and inner surface **103B** to provide motion isolation.

[0103] For example, FIG. 10 is a stress-strain diagram **106** showing a stress-strain relationship **108** for the thermoplastic material **104** and a stress-strain relationship **110** for the ther-

moset material **102**. The stress-strain diagram **106** also includes a stress-strain relationship **112** for the cushion structure **100** of FIG. 9. The stress-strain relationship **112** of the cushion structure **100** may be disposed between those of the thermoset material **102** and the thermoplastic material **104**, which both contribute their performance characteristics to the cushion structure **100**.

[0104] FIGS. 11A-11E show further stress-strain relationships illustrating different performance characteristics which may be achieved by modifying the material attributes of the cushion structure **100**. For example, FIG. 11A depicts a performance curve **114(1)** of a mattress assembly formed of low-density thermoset which may be too soft. The user may sink in the sleeping surface to a depth that is too deep and then “bottom out.” FIG. 11B depicts a performance curve **114(2)** reflecting a mattress that is too hard. The user may apply a variety of weight to the mattress causing a variety of stress, but the mattress surface may not move much in response, resulting in a user experience analogous to sleeping on a floor.

[0105] The shape of the performance curve may be as important as the slope of the performance curve. For example, FIG. 11C depicts a performance curve **114(3)** of a mattress that is initially too soft as the user first applies their weight to the all-foam mattress assembly. The all-foam mattress assembly offers no transition zone and immediately is too hard resulting in a negative overall experience for the user.

[0106] FIG. 11D depicts a performance curve **114(4)** for a mattress that is initially harder than the performance curve **114(3)** of FIG. 11C, but yet also delivers a negative user experience because there is an abrupt “bottoming-out” at some strain amount where the performance curve **114(4)** steepens too rapidly. The user may find the initial performance of the mattress prior to the bottoming-out as pleasant, but the bottoming-out quite unsettling.

[0107] FIG. 11E depicts a performance curve **114(5)** of a mattress that provides the most ideal user experience. The initial strain is provided without being too soft and there is gradual strain with increasing stress provided by the user. As higher amounts of strain are reached, there is no bottoming out as was experienced in the performance curves **114(3)** and **114(4)**. Instead, the mattress allows a gradual linear response that is supportive as the stress and strain are increased.

[0108] Now that the material selection has been discussed above in relation to the reduction efforts in FIGS. 9A through 11E, different thermoplastic profiles are discussed in relation to FIG. 12 that may provide the proper stress-strain profile for support and comfort for the user while reducing density of the foam engineered core **56**.

[0109] In this regard, FIG. 12 provides an exemplary chart **116** of performance curves showing strain (deflection) under a given stress (pressure) for different types of thermoplastic foam cushioning structures to show the advantage of using thermoplastic in combination with thermoset to provide the desired firmness and support characteristics in the cushioning structure **100**. A performance curve **118** illustrates the result of testing of strain for a given stress of an exemplary solid block of low density polyethylene foam before being engineered into a particular profile. Performance curves **120**, **122** represent the result of testing of strain for a given stress of two exemplary polyethylene foam extrusion profiles formed from the low density polyethylene foam represented by the performance curve **118**. As illustrated in FIG. 12, the low density polyethylene foam represented by the performance curve **118** supports a higher load or stress than the two polyethylene

foam extrusion profiles represented by the performance curves **120**, **122** of the same or similar density. Further, as illustrated in FIG. 12, the polyethylene foam extrusion profile represented by the performance curve **120** illustrates strain for a given stress that has a greater propensity to support a higher load than the exemplary polyethylene foam extrusion profile represented by the performance curve **122**. Thus, a thermoplastic foam profile can be engineered to be less supportive to be more similar to thermoset material in the cushioning structure **100** depending on the support characteristics for the cushioning structure **100** desired. The cushioning structure **100** may be analogous to the foam engineered core where the same thermoset and thermoplastic may be used to achieve the desired cushioning and support characteristics which may be quantified using a stress-strain curve.

[0110] Now that the different thermoplastic profiles have been discussed above in relation to the reduction efforts in FIG. 12, the introduction of bulk-free volume **76** in combination with various thermoplastic profiles will be discussed in FIG. 13 through 19 for three (3) different thermoplastic profiles and foam mattress cores of all-foam mattress assemblies to provide the proper stress-strain profile for support and comfort for the user while reducing density of the foam engineered core **56**.

[0111] In this regard, FIG. 13 is a stress-strain chart **130** depicting stress-strain relationships **131**, **132**, **134**, **136** for embodiments of portions **75**, (see FIG. 3B), **138** (see FIG. 14), **140** (see FIG. 16), **142** (see FIG. 18) of foam engineered cores, respectively. The stress-strain relationship **132** provides the most support because it requires the most stress to create a given strain. The stress-strain relationship **134** may be the most flexible, because it requires the least stress to create a given strain. The stress-strain relationship **136** may not too stiff or most flexible, because it requires a medial amount of stress to create a given strain. The stress-strain relationships **131**, **132**, **134**, **136** for the portion of the foam engineered core **56** may be represented numerically by a fourth order polynomial with the following coefficients in Table 1 based on the equation $Y=a_4*X^4+a_3*X^3+a_2*X^2+a_1*X+a_0$, wherein the X is strain in percent, and Y=stress in pascals for values of X between 15 to 42 percent. Using the fourth order polynomial for stress-strain relationship **132**, for example, for a strain of 40 percent, X=40, and Y=11,809 pascals.

TABLE 1

Polynomial Coefficients of Fourth Order Polynomial Best Fit Lines For FIG. 13 - Stress-Strain Relationships 131, 132, 134, 136				
Polynomial Coefficient	Stress-strain relationship “131”	Stress-strain relationship “132”	Stress-strain relationship “134”	Stress-strain relationship “136”
a_4	0.012143	0.0013636	0.0029545	0.0029924
a_3	-0.7467	0.13636	-0.187879	-0.1118687
a_2	10.03761	-7.06061	2.174242	0.5568182
a_1	346.196	273.182	98.9177	171.3276
a_0	-123.5391	-39.3939	11.4719	44.3723

[0112] FIG. 14 depicts a side view of the foam engineered core **138** and FIG. 15A depicts a portion of a foam engineered core **138** in an exemplary all-foam mattress assembly **50-6** of a mattress **51-6**. The portion of the foam engineered core **138** may comprise an engineered geometric thermoplastic material profile **58-6** thermally bonded to a load distribution mem-

ber 68, with the engineered geometric thermoplastic material profile 58-6 surrounding a thermoset member 60-6 which may be bonded to the engineered geometric thermoplastic material profile 58-6 with a stratum 101. In this manner, a stiffer version of the foam engineered core 138 may be created. It is also noted that the portion of the foam engineered core 138 includes fifty (50) percent thermoplastic, thirty-two (32) percent thermoset, and eighteen (18) percent bulk-free volume 76. The thermoplastic of the engineered geometric thermoplastic material profile 58-6 may be, for example, polyethylene with a density of fifteen (15) pounds per cubic foot. The thermoset of the thermoset member 60-6 may be, for example, polyurethane with a density between 1.8 and 2.6 pounds per cubic foot. The bulk-free volume 76 may be considered to have a zero (0) weight contribution. Accordingly, a less dense embodiment of the all-foam mattress assembly 50-6 may be created by replacing portions of the thermoset member 60-6 with either bulk-free volume 76 and/or the engineered geometric thermoplastic material profile 58-6.

[0113] It is noted that a preferred stress strain relationship for the portion of the foam engineered core 56 may be within a range of acceptable values as perceived by users and may be less than the stress-strain relationship 131 and/or the stress-strain relationship 132. The preferred stress-strain relationship may also be greater than the stress-strain relationship 134 and/or the stress-strain relationship 136. In this manner, a foam engineered core 56 with low density may provide the cushion and support characteristics desired by the user.

[0114] The density of the thermoplastic used, the density of the thermoset used, as well as the volumetric percentages of thermoplastic, thermoset, and bulk volume are shown in Table 2 for the embodiment of the portion of the foam engineered core 56 shown in FIG. 14 as well as those shown in FIGS. 2, 16 and 18.

TABLE 2

Thermoplastic Density, Thermoset Density, and Volumetric Percentages of Thermoset, Thermoplastic and Bulk-Free Volume For Portions of The Foam Engineered Cores					
Embodiment	Thermoplastic Density (lbs/ft ³)	Thermoset Density (lbs/ft ³)	Thermoplastic Volume (percent)	Thermoset Volume (percent)	Bulk-Free Volume (percent)
FIG. 2	1.5	2.0	51	16	33
FIG. 14	1.5	2.0	50	32	18
FIG. 16	1.5	2.3	36	26	38
FIG. 18	1.5	2.0	51	17	32

[0115] It is noted that the portion of the foam engineered core 138 may comprise an engineered geometric thermoplastic material profile 58-6 thermally bonded to a load distribution member 68, with the engineered geometric thermoplastic material profile 58-6 surrounding and adjacent to a thermoset member 60-6 and free of a stratum 101'. In the case where the portion of the foam engineered core 138 of FIG. 14 may be free of the stratum 101, then the stress-strain relationship 134, represented in FIG. 15B as stress-strain relationship 134', may be lowered to the stress-strain relationship 137 as shown in a chart 135 depicted in FIG. 15B. In this manner removing the stratum 101' causes the portion of the foam engineered core 138 of FIG. 14 to be more flexible.

[0116] FIG. 16 depicts a side view of the foam engineered core 140 and FIG. 17 depicts a portion of a foam engineered

core 140 in an exemplary all-foam mattress assembly 50-7 of a mattress 51-7. The portion of the foam engineered core 140 may comprise an engineered geometric thermoplastic material profile 58-7 thermally bonded to a load distribution member 68-7, with the engineered geometric thermoplastic material profile 58-7 surrounding a thermoset member 60-7 which may be bonded to the engineered geometric thermoplastic material profile 58-7. In this manner, a less stiff version of the foam engineered core 140 may be created. It is also noted that the portion of the foam engineered core 140 includes thirty-six (36) percent thermoplastic, twenty-six (26) percent thermoset, and thirty-eight (38) percent bulk-free volume 76. The thermoplastic of the engineered geometric thermoplastic material profile 58-7 may be, for example, polyethylene with a density of fifteen (15) pounds per cubic foot. The thermoset of the thermoset member 60-7 may be, for example, polyurethane with a density between 1.8 and 2.6 pounds per cubic foot. The bulk-free volume 76 may be considered to have a zero (0) weight contribution. Accordingly, a less dense embodiment of the all-foam mattress assembly 50-7 may be created by replacing portions of the thermoset member 60-7 with either bulk-free volume 76 and/or the engineered geometric thermoplastic material profile 58-7.

[0117] FIG. 18 depicts a side view of the foam engineered core 142 and FIG. 19 depicts a portion of a foam engineered core 142 in an exemplary all-foam mattress assembly 50-8 of a mattress 51-8. The portion of the foam engineered core 142 may comprise an engineered geometric thermoplastic material profile 58-8 thermally bonded to a load distribution member 68, with the engineered geometric thermoplastic material profile 58-8 surrounding a thermoset member 60-8 which may be bonded to the engineered geometric thermoplastic material profile 58-8. In this manner, a medial stiffness version of the foam engineered core 142 may be created. It is also noted that the portion of the foam engineered core 142 includes forty-one (41) percent thermoplastic, twenty-two (22) percent thermoset, and thirty-seven (37) percent bulk-free volume 76. The thermoplastic of the engineered geometric thermoplastic material profile 58-8 may be, for example, polyethylene with a density of fifteen (15) pounds per cubic foot. The thermoset of the thermoset member 60-8 may be, for example, polyurethane with a density between 1.8 and 2.6 pounds per cubic foot. The bulk-free volume 76 may be considered to have a zero (0) weight contribution. Accordingly, a less dense embodiment of the all-foam mattress assembly 50-8 may be created by replacing portions of the thermoset member 60-8 with either bulk-free volume 76 and/or the engineered geometric thermoplastic material profile 58-8. It is noted that this portion of the foam engineered core 142 comprises a thermoplastic support member 72-8 which contains a first spring bore 74A-8.

[0118] Now that the bulk-free volume 76 has been discussed in combination with various thermoplastic profiles in FIG. 13 through 19 for three (3) different thermoplastic profiles, different embodiments of foam engineered cores with reference to FIGS. 20 through 26 are now discussed as a possibility to reduce density of the foam engineered core 56.

[0119] FIG. 20 depicts a top perspective view of another exemplary all-foam mattress assembly 148-1 within another exemplary mattress 150-1 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mat-

treass assembly 148-1 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity.

[0120] With continuing reference to FIG. 20, the foam engineered core 56 may include the load distribution member 68 and the decks 62(1), 62(2). The foam engineered core 56 may also include the plurality of thermoset members 60(1)-60(n) adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) in a parallel arrangement. The foam engineered core 56 may also include a plurality of thermoplastic support members 72(1)-72(p) disposed between the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n). The foam engineered core 56 may also include bulk-free volume 76, in this case within the thermoplastic support members 72(1)-72(p) and between the engineered geometric thermoplastic material profiles 58(1)-58(n). It is noted that the exemplary mattress 150-1 includes optional side supports 154(1), 154(2) and optional side support cushions 156(1), 156(2) which may be disposed around a perimeter of the foam engineered core 56. In this manner, the combination of the engineered geometric thermoplastic material profiles 58(1)-58(n) and the bulk-free volume 76 utilized in the mattress 150-1 results in a lighter, less dense mattress which is easier to maintain and transport.

[0121] FIG. 21 depicts a top perspective view of another exemplary all-foam mattress assembly 148-2 within another exemplary mattress 150-2 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mattress assembly 148-2 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity.

[0122] With reference to FIG. 21, the foam engineered core 56 may include the load distribution member 68 and the decks 62(1), 62(2). The foam engineered core 56 may also include the plurality of thermoset members 60(1)-60(n) adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) in a parallel arrangement. The foam engineered core 56 may also include bulk-free volume 76, in this case between the engineered geometric thermoplastic material profiles 58(1)-58(n). It is noted that the exemplary mattress 150-2 includes optional side supports 154(1), 154(2) and optional side support cushions 156(1), 156(2) which may be disposed around a perimeter of the foam engineered core 56. In this manner, the combination of the engineered geometric thermoplastic material profiles 58(1)-58(n) and the bulk-free volume 76 utilized in the mattress 150-2 results in a lighter, less dense mattress which is easier to maintain and transport.

[0123] FIG. 22 depicts a top perspective view of another exemplary all-foam mattress assembly 148-3 within another exemplary mattress 150-3 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mattress assembly 148-3 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity. With reference to FIG. 22, the foam engineered core 56 may include the load distribution member 68 and the decks 62(1), 62(2). The foam engineered core 56 may also include the plurality of thermoset members 60(1)-60(p) adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) in a parallel arrangement. The foam engineered core 56 may also include bulk-free volume 76, in this case between the engineered geometric thermoplastic material profiles 58(1)-58(n). It is noted that the exem-

plary mattress 150-3 includes optional side supports 154(1), 154(2) and optional side support cushions 156(1), 156(2) which may be disposed around a perimeter of the foam engineered core 56. In this manner, the combination of the engineered geometric thermoplastic material profiles 58(1)-58(n) and the bulk-free volume 76 utilized in the mattress 150-3 results in a lighter, less dense mattress which is easier to maintain and transport.

[0124] FIG. 23 depicts a top perspective view of another exemplary all-foam mattress assembly 148-4 within another exemplary mattress 150-4 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mattress assembly 148-4 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity. With reference to FIG. 23, the foam engineered core 56 may include the load distribution member 68 and the decks 62(1), 62(2). The foam engineered core 56 may also include the plurality of thermoset members 60(1)-60(n) adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) in a parallel arrangement. The foam engineered core 56 may also include bulk-free volume 76, in this case between the engineered geometric thermoplastic material profiles 58(1)-58(n). It is noted that the exemplary mattress 150-4 includes optional side supports 154(1), 154(2) and optional side support cushions 156(1), 156(2) which may be disposed around a perimeter of the foam engineered core 56. In this manner, the combination of the engineered geometric thermoplastic material profiles 58(1)-58(n) and the bulk-free volume 76 utilized in the mattress 150-4 results in a lighter, less dense mattress which is easier to maintain and transport.

[0125] FIG. 24 depicts a front side view of another exemplary all-foam mattress assembly 148-5 within another exemplary mattress 150-5 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mattress assembly 148-5 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity. With reference to FIG. 24, the foam engineered core 56 may include the load distribution member 68 and the decks 62(1), 62(2). The foam engineered core 56 may also include the plurality of thermoset members 60(1)-60(n) adjacent to the plurality of engineered geometric thermoplastic material profiles 58(1)-58(n) in a parallel arrangement. The foam engineered core 56 may also include bulk-free volume 76, in this case between and within the engineered geometric thermoplastic material profiles 58(1)-58(n). It is noted that the exemplary mattress 150-5 includes optional side supports 154(1), 154(2) and optional side support cushions 156(1), 156(2) which may be disposed around a perimeter of the foam engineered core 56. In this manner, the combination of the engineered geometric thermoplastic material profiles 58(1)-58(n) and the bulk-free volume 76 utilized in the mattress 150-5 results in a lighter, less dense mattress which is easier to maintain and transport.

[0126] FIG. 25 depicts a top perspective view of another exemplary all-foam mattress assembly 148-6 within another exemplary mattress 150-6 having the foam comfort layers 52(1), 52(2), the foam transitional layer 54, and a foam engineered core 56. The differences between the all-foam mattress assembly 148-6 and the all-foam mattress assembly 50-1 of FIG. 2 may be discussed to eliminate redundancy and foster clarity. With reference to FIG. 25, the foam engineered

core **56** may include the load distribution member **68** and the decks **62(1)**, **62(2)**. The foam engineered core **56** may also include the plurality of thermoset members **60(1)-60(n)** adjacent to the plurality of engineered geometric thermoplastic material profiles **58(1)-58(n)** in a parallel arrangement. The foam engineered core **56** may also include a plurality of thermoplastic support members **72(1)-72(p)** disposed between the plurality of engineered geometric thermoplastic material profiles **58(1)-58(n)**. The foam engineered core **56** may also include bulk-free volume **76**, in this case between the engineered geometric thermoplastic material profiles **58(1)-58(n)** and within the thermoplastic support members **72(1)-72(p)**. It is noted that the exemplary mattress **150-6** includes optional side supports **154(1)**, **154(2)** and optional side support cushions **156(1)**, **156(2)** which may be disposed around a perimeter of the foam engineered core **56**. In this manner, the combination of the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the bulk-free volume **76** utilized in the mattress **150-6** results in a lighter, less dense mattress which is easier to maintain and transport.

[0127] FIG. 26 depicts a top perspective view of another exemplary all-foam mattress assembly **148-7** within another exemplary mattress **150-7** having the foam comfort layers **52(1)**, **52(2)**, the foam transitional layer **54**, and a foam engineered core **56**. The differences between the all-foam mattress assembly **148-7** and the all-foam mattress assembly **50-1** of FIG. 2 may be discussed to eliminate redundancy and foster clarity. With reference to FIG. 26, the foam engineered core **56** may include the load distribution member **68** and the decks **62(1)**, **62(2)**. The foam engineered core **56** may also include the plurality of thermoset members **60(1)-60(n)** adjacent to the plurality of engineered geometric thermoplastic material profiles **58(1)-58(n)** in a parallel arrangement. The foam engineered core **56** may also include a plurality of thermoplastic support members **72(1)-72(p)** disposed between the engineered geometric thermoplastic material profiles **58(1)-58(n)**. The foam engineered core **56** may also include bulk-free volume **76**, in this case between the engineered geometric thermoplastic material profiles **58(1)-58(n)** and within the thermoplastic support members **72(1)-72(p)**. It is noted that the exemplary mattress **150-7** includes optional side supports **154(1)**, **154(2)** and optional side support cushions **156(1)**, **156(2)** which may be disposed around a perimeter of the foam engineered core **56**. In this manner, the combination of the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the bulk-free volume **76** utilized in the mattress **150-7** results in a lighter, less dense mattress which is easier to maintain and transport.

[0128] Now that different embodiments of foam engineered cores with reference to FIGS. 20 through 26 have been introduced, different embodiments of thermoplastic profiles may be discussed in regard to FIGS. 27 through 36D as potential components to reduce density of the foam engineered core **56**.

[0129] FIGS. 27A-27I are top perspective views of alternative cellular thermoplastic foam profiles **160A-160I**, respectively, that may serve as one of a plurality of thermoplastic support members within a foam engineered core, or may be encapsulated or filled with a thermoset material to serve as one of a plurality of engineered geometric thermoplastic material profiles within the foam engineered core. The thermoplastic foam profiles **160A-160I** may be provided according to any of the embodiments disclosed herein for providing a thermoplastic foam profile, a thermoplastic foam profile

with thermoset disposed therein, or a unitary composite cushioning structure with thermoset bonded to thermoplastic with a stratum. As illustrated therein, thermoplastic foam profiles **160A-160I** may be constructed out of a thermoplastic material including foam. The thermoplastic foam profiles **160A-160I** may have one or more chambers **162A-162I**, which may be open or closed and which can either be left void or filled with a thermoset material to provide a unitary composite cushioning structure. The thermoplastic foam profiles **160A-160I** can also be encapsulated with a thermoset material in addition to or in lieu of being filled with a thermoset material as part of a composite structure. All other possibilities for thermoplastic foam profiles, thermoset materials, and unitary composite cushioning structures discussed above are also possible for the thermoplastic foam profiles **160A-160I** in FIGS. 27A-27I.

[0130] As another example, FIGS. 28A and 28B are a perspective view and a side view, respectively, of another exemplary cushioning structure **170** which may serve within the foam engineered core **56** as either one of the thermoplastic support members **72(1)-72(n)** or as one of the engineered geometric thermoplastic material profiles **58(1)-58(n)**. The cushioning structure **170** may be comprised of a plurality of unitary cushioning structures **172**. The unitary cushioning structures **172** may be attached to each other either cohesively or adhesively in a side-by-side arrangement or extruded as one piece, wherein each comprises an outer material **174** with openings **176**, **178** disposed therein. A core material **180** may be disposed in either or both of the openings **176**, **178** if desired, as shown in the cushioning structure **170** in FIG. 28A. Each of the cushioning structure **170** may be configured to be extruded with the openings **176**, **178** present as one piece. The outer material **174** may be comprised of a cellular thermoplastic material and the core material **180** comprised of thermoset material, or vice versa. Alternatively, the core material **180** may not be included to provide hollow portions disposed within the openings **176**, **178**.

[0131] As another example, FIG. 28C illustrates a side profile of another exemplary cushioning structure **182** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The cushioning structure **182** may be comprised of a plurality of unitary cushioning structures **184**. The unitary cushioning structures **184** may be attached to each other either cohesively or adhesively in a side-by-side arrangement or extruded as one piece, wherein each may comprise an outer material **186** with openings **188**, **190** disposed therein. A core material **192** may be disposed in either or both of the openings **188**, **190** if desired, as shown in FIG. 28C. Each of the unitary cushioning structure **184** may be extruded with the openings **188**, **190** present as one piece. The outer material **186** may be comprised of a cellular thermoplastic material and the core material **192** may be comprised of thermoset material, or vice versa. Alternatively, the core material **192** may not be included to provide hollow portions disposed within the openings **188**, **190**. Additional openings **194** may be formed by the arrangement of the unitary cushioning structures **184** being disposed side-by-side.

[0132] As another example, FIG. 28D illustrates a side profile of another exemplary unitary composite cushioning structure **196** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**.

The unitary composite cushioning structure **196** may be comprised of a plurality of unitary cushioning structures **198**. The unitary cushioning structures **198** may be attached to each other either cohesively or adhesively in a side-by-side arrangement or extruded as one piece, wherein each comprises an outer material **200** with openings **202A**, **202B**, **204** disposed therein. A core material **206** may be disposed in some or all of the openings **202A**, **202B**, **204** if desired, as shown in FIG. **28D**. Each of the unitary cushioning structures **198** may be extruded with the openings **202A**, **202B**, **204** present as one piece. The outer material **200** may be comprised of a cellular thermoplastic material and the core material **206** may be comprised of thermoset material, or vice versa. Alternatively, the core material **206** may not be included to provide hollow portions disposed within the openings **202A**, **202B**, **204**. Additional openings **208** may be formed by the arrangement of the unitary cushioning structures **198** being disposed side-by-side.

[0133] As another example, FIG. **29A** illustrates a side profile of another exemplary unitary composite cushioning structure **210** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The unitary composite cushioning structure **210** may comprise a first layer **212** of a closed composite cushioning structure **214A** to provide a base cushioning and support structure. The unitary composite cushioning structure **210** comprises an outer material **216** arranged to provide side-by-side triangular structures **218A-218C** each having openings **220A-220C** disposed therein. A core material **222A-222C** may be disposed in the openings **220A-220C**, if desired. The outer material **216** may be extruded with the openings **220A-220C** present as one piece. The outer material **216** may be comprised of a cellular thermoplastic material and the core material **222A-222C** comprised of thermoset material, or vice versa. Alternatively, the core material **222A-222C** may not be included to provide a hollow portion disposed within the openings **220A-220C**. With continuing reference to FIG. **29A**, a second layer **224** may comprise a composite cushioning structure **214B** that may be the same as the structure **214A** provided in the first layer **212**, but flipped one-hundred eighty (180) degrees and disposed on top of the first layer **212** and secured either cohesively or adhesively. In this manner, additional openings **226A**, **226B** may be disposed in the unitary composite cushioning structure **210**. FIG. **29B** illustrates a unitary composite cushioning structure **210'** that may be the same as the unitary composite cushioning structure **210**, except that ends **228A**, **228B** may be closed off to form additional openings **230A**, **230B**.

[0134] As another example, FIG. **30** illustrates a side profile of another exemplary unitary composite cushioning structure **232** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The unitary composite cushioning structure **232** may comprise a first layer **234** of a closed composite cushioning structure **236A** to provide a base cushioning and support structure. The closed composite cushioning structure **236A** comprises an outer material **238** arranged to provide three (3) side-by-side circular structures **240A-240C** each having openings **242A-242C** disposed therein. A core material **244A-244C** may be disposed in the openings **242A-242C** if desired. The outer material **238** may be extruded with the openings **242A-242C** present as one piece. The outer material **238** may be com-

prised of a cellular thermoplastic material and the core material **244A-244C** comprised of thermoset material, or vice versa. Alternatively, the core material **244A-244C** may not be included to provide a hollow portion disposed within the openings **242A-242C**. With continuing reference to FIG. **30**, a second layer **246** comprised of a composite cushioning structure **236B** that may be the same as provided in the first layer **234** may be provided and disposed atop the first layer **234** and secured either cohesively or adhesively.

[0135] As another example, FIG. **31A** illustrates a side profile of another exemplary unitary composite cushioning structure **248** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The unitary composite cushioning structure **248** may be comprised of a first layer **250** of a closed unitary composite cushioning structure **252** to provide a base cushioning and support structure. The unitary composite cushioning structure **252** may comprise an outer material **254** with openings **256** disposed therein. A core material **258** may be disposed in the openings **256** if desired. The outer material **254** may be extruded with the openings **256** present. The outer material **254** may be comprised of a cellular thermoplastic material and the core material **258** may be comprised of thermoset material, or vice versa. Alternatively, the core material **258** may not be included to provide a hollow portion disposed within the outer material **254**. With continuing reference to FIG. **31A**, a second layer **260** of an open cushioning structure **262** comprised of an outer material **264** having a structure **266** with an opening **268** disposed therein.

[0136] As another example, FIG. **31B** illustrates a side profile of another exemplary unitary composite cushioning structure **270** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The unitary composite cushioning structure **270** may be comprised of a first layer **272** of a closed unitary composite cushioning structure **274** to provide a base cushioning and support structure. The closed unitary composite cushioning structure **274** comprises an outer material **276** with openings **278** disposed therein. A core material **280** may be disposed in the openings **278** if desired. The outer material **276** may be extruded with the openings **278** present. The outer material **276** may be comprised of a cellular thermoplastic material and the core material **280** comprised of thermoset material, or vice versa. Alternatively, the core material **280** may not be included to provide a hollow portion disposed within the outer material **276**. With continuing reference to FIG. **31B**, a second layer **282** of an open cushioning structure **284** comprised of an outer material **286** having a structure **288** with an opening **290** disposed therein. It is noted that the structure **288** of FIG. **31B** may be larger than the structure **266** of FIG. **31A** to provide additional support for the user.

[0137] As another example, FIG. **32** illustrates a side profile of another exemplary unitary composite cushioning structure **300** which may serve within the foam engineered core **56** as the engineered geometric thermoplastic material profiles **58(1)-58(n)** and the thermoset members **60(1)-60(n)**. The unitary composite cushioning structure **300** may be comprised of a first layer **302** of a closed unitary composite cushioning structure **304** to provide a base cushioning and support structure. The closed unitary composite cushioning structure **304** comprises an outer material **306** with openings **308** disposed therein. A core material **310** may be disposed in

the openings 308 if desired. The outer material 306 may be extruded with the openings 308 present. The outer material 306 may be comprised of a cellular thermoplastic material and the core material 310 comprised of thermoset material, or vice versa. Alternatively, the core material 310 may not be included to provide a hollow portion disposed within the outer material 306.

[0138] With continuing reference to FIG. 32, a second layer 312 of closed cushioning structures 314A, 314B comprised of an outer materials 316A, 316B having openings 318A, 318B disposed therein with extension members 320A, 320B may be disposed atop the first layer 302 in the Y direction either cohesively or adhesively. A core material 322A, 322B may be disposed within the openings 318A, 318B of the cushioning structures 314A, 314B if desired. The cushioning structures 314A, 314B may be comprised of a cellular thermoplastic material and the core materials 322A, 322B may comprise thermoset material, or vice versa. Alternatively, the core materials 322A, 322B may not be included to provide a hollow portion disposed within the cushioning structures 314A, 314B.

[0139] As another example, FIG. 33 illustrates a side profile of another exemplary unitary composite cushioning structure 324 which may serve within the foam engineered core 56 as the engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n). The unitary composite cushioning structure 324 may contain the same second layer 312 as in FIG. 32. However, a first layer 326 of the unitary composite cushioning structure 324 may comprise an alternative closed unitary composite cushioning structure 328 to provide a base cushioning and support structure. The unitary composite cushioning structure 324 comprises an outer material 330 with openings 332 disposed therein. The openings 332 are semi-circular shaped in this embodiment. A core material 334 may be disposed in the openings 332 if desired. The outer material 330 may be extruded with the openings 332 present. The outer material 330 may be comprised of a cellular thermoplastic material and the core material 334 comprised of thermoset material, or vice versa. Alternatively, the core material 334 may not be included to provide a hollow portion disposed within the outer material 330. Circular voids 332A, 332B may be disposed on ends 334A, 334B of the first layer 326.

[0140] As another example, FIG. 34 illustrates a side profile of another exemplary unitary composite cushioning structure 336 which may serve within the foam engineered core 56 as the engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n). The unitary composite cushioning structure 336 may comprise a first layer 338 including a closed unitary composite cushioning structure 340 to provide a base cushioning and support structure. The closed unitary composite cushioning structure 340 may comprise an outer material 342 with openings 344, 346, 348 disposed therein with a core material 350 disposed in the openings 344, 346, 348 to provide the closed unitary composite cushioning structure 340. The outer material 342 may be extruded with the openings 344, 346, 348 present, or the openings 344, 346, 348 may be portions of the outer material 342 cut from internal portions. The outer material 342 may be comprised of a cellular thermoplastic material and the core material 350 comprised of thermoset material, or vice versa. Alternatively, the core material 350 may not be included to provide a hollow portion disposed within the outer material 342.

[0141] With continuing reference to FIG. 34, a second layer 352 of a cushioning structure 354 may be provided in the form of an arch-shaped member with an open profile disposed atop of the first layer 338 in the Y direction either cohesively or adhesively. A core material 356 may be disposed within the cushioning structure 354 if desired. The cushioning structure 354 may comprise a cellular thermoplastic material and the core materials 356 may comprise thermoset material, or vice versa. Alternatively, the core material 356 may not be included to provide a hollow portion disposed within the cushioning structure 354.

[0142] As another example, FIG. 35A illustrates a side profile of another exemplary unitary composite cushioning structure 358 which may serve within the foam engineered core 56 as the engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n). The unitary composite cushioning structure 358 may be comprised of a first layer 360 of closed unitary composite cushioning structures 362A, 362B arranged side-by-side and cohesively or adhesively attached to each other to provide a base cushioning and support structure. Each of the unitary composite cushioning structures 362A, 362B comprise an outer material 364A, 364B with openings 366A, 366B, 368A, 368B, 370A, 370B disposed therein with a core material 372A, 372B disposed in the openings 366A-370B to provide the unitary composite cushioning structures 362A, 362B. The outer materials 364A, 364B may be extruded with the openings 366A-370B present, or the openings 366A-370B may be portions of the outer materials 364A, 364B cut from internal portions. The outer materials 364A, 364B may comprise a cellular thermoplastic material and the core materials 372A, 372B may comprise thermoset material, or vice versa. Alternatively, the core materials 372A, 372B may not be included to provide a hollow portion disposed within the outer materials 364A, 364B.

[0143] With continuing reference to FIG. 35A, a second layer 374 of cushioning structures 376A, 376B arranged side-by-side and each provided in the form of an arch-shaped member with an open profile is disposed on top of the first layer 360 in the Y direction either cohesively or adhesively. Core materials 378A, 378B may be disposed within the cushioning structures 376A, 376B if desired. The cushioning structures 376A, 376B may comprise a cellular thermoplastic material and the core materials 378A, 378B may comprise thermoset material, or vice versa. Alternatively, the core materials 378A, 378B may not be included to provide a hollow portion disposed within the cushioning structures 376A, 376B.

[0144] As another example, FIG. 35B illustrates a side profile of another exemplary unitary composite cushioning structure 380 which may serve within the foam engineered core 56 as the engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n). The unitary composite cushioning structure 380 may be similar to the unitary composite cushioning structure 358 in FIG. 35A, except that the first layer provides a modified profile. In this regard, the unitary composite cushioning structure 380 may comprise a first layer 382 of closed unitary composite cushioning structures 384A, 384B arranged side-by-side and cohesively or adhesively attached to each other to provide a base cushioning and support structure. Each of the unitary composite cushioning structure 384A, 384B may comprise an outer material 386A, 386B with openings 388A, 388B, 390A, 390B, 392A, 392B disposed therein with a core mate-

rial 394A, 394B disposed in the openings 388A-392B to provide the unitary composite cushioning structures 384A, 384B. The outer materials 386A, 386B may be extruded with the openings 388A-392B present, or the openings 388A-392B may be portions of the outer materials 386A, 386B cut from internal portions. The outer materials 386A, 386B may comprise a cellular thermoplastic material and the core materials 394A, 394B may comprise thermoset material, or vice versa. Alternatively, the core materials 394A, 394B may not be included to provide a hollow portion disposed within the outer materials 386A, 386B.

[0145] With continuing reference to FIG. 35B, a second layer 396 of cushioning structures 398A, 398B arranged side-by-side and each provided in the form of an arch-shaped member with an open profile is disposed on top of the first layer 382 in the Y direction either cohesively or adhesively. Core materials 400A, 400B may be disposed within the cushioning structures 398A, 398B if desired. The cushioning structures 398A, 398B may comprise a cellular thermoplastic material and the core materials 400A, 400B may comprise thermoset material, or vice versa. Alternatively, the core materials 400A, 400B may not be included to provide a hollow portion disposed within the cushioning structures 398A, 398B.

[0146] As another example, FIG. 36A illustrates a side profile view of another unitary composite cushioning structure 402(1). The unitary composite cushioning structure 402(1) may include an outer material 404 having the closed profile. The profile of the unitary composite cushioning structure 402(1) may comprise a base portion 406 and a head portion 408 having neck portions 410A, 410B disposed therebetween. The profile of the neck portions 410A, 410B may define the size and shape of the head portion 408. A core material 412 may be disposed inside an opening 414 disposed in the outer material 404 to provide the unitary composite cushioning structure 402(1). The outer material 404 may comprise a cellular thermoplastic material and the core material 412 may comprise thermoset material, or vice versa. Alternatively, the core material 412 may not be included to provide a hollow portion disposed within the outer material 404.

[0147] As another example, FIG. 36B illustrates a side profile view of another unitary composite cushioning structure 402(2). The unitary composite cushioning structure 402(2) may include an outer material 416 having an open profile with opening 418. The profile of the unitary composite cushioning structure 402(2) may comprise a base portion 420 and a head portion 422 having neck portions 424A, 424B disposed therebetween. The profile of the neck portions 424A, 424B may define a size and shape of the head portion 422. A core material 426 may be disposed inside the base portion 420. The base portion 420 may comprise a cellular thermoplastic material and the core material 426 may comprise thermoset material, or vice versa. An intermediate material 428 may be disposed inside the head portion 422, which may be disposed around a core material 430, as illustrated in FIG. 36B. The outer material 416, the intermediate material 428, and the core material 426 may comprise a cellular thermoplastic material or thermoset materials, in any combination of each.

[0148] FIGS. 36C and 36D illustrate the same head portion 422 in FIG. 36B, but with different base portion arrangements. In FIG. 36C, a unitary composite cushioning structure 402(3) is provided that provides core material 426A, 426B

only in smaller, separate designated portions of the base portion 420. In the unitary composite cushioning structure 402(4) in FIG. 36D, a base portion 432 may be provided which includes a different profile with a base material 434 not including openings for disposition of a core material. It is noted that the unitary composite cushioning structures 402(1)-402(4) may serve within the foam engineered core 56 as the engineered geometric thermoplastic material profiles 58(1)-58(n) and the thermoset members 60(1)-60(n).

[0149] Many modifications of the embodiments set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

We claim:

1. An all-foam mattress assembly, comprising:
 - at least one foam comfort layer to receive a load of a user;
 - at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and
 - a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, bulk-free volume, and a deck, wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck.
2. The all-foam mattress assembly of claim 1, wherein the foam engineered core further comprises a load distribution member configured to receive the load conveyed by the at least one foam transitional layer,
 - wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are configured to collectively receive the load from the load distribution member.
3. The all-foam mattress assembly of claim 2, wherein the at least one foam transitional layer is configured to move in a horizontal plane with respect to the load distribution member.
4. The all-foam mattress assembly of claim 3, wherein the at least one foam transitional layer comprises a planar surface configured to communicate with a planar surface of the load distribution member.
5. The all-foam mattress assembly of claim 4, wherein the foam engineered core further comprises a plurality of thermoplastic support members arranged in the parallel arrangement and disposed between the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members.
6. The all-foam mattress assembly of claim 5, wherein the plurality of thermoplastic support members, the plurality of

engineered geometric thermoplastic material profiles, and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck.

7. The all-foam mattress assembly of claim 1, wherein the at least one foam comfort layer comprises thermoset.

8. The all-foam mattress assembly of claim 1, wherein the deck comprises thermoplastic.

9. The all-foam mattress assembly of claim 8, wherein the at least one engineered geometric thermoplastic material profile comprises polyethylene.

10. The all-foam mattress assembly of claim 1, wherein the foam engineered core abuts against the at least one foam transitional layer.

11. The all-foam mattress assembly of claim 1, wherein the deck includes at least one channel configured to be orthogonal to the load.

12. The all-foam mattress assembly of claim 11, wherein the at least one channel may be filled or substantially filled with thermoset material.

13. The all-foam mattress assembly of claim 2, wherein the plurality of engineered geometric thermoplastic material profiles may be disposed between the load distribution member and the deck, and secured to the load distribution member.

14. The all-foam mattress assembly of claim 1, wherein the plurality of thermoset members and the at least one foam comfort layer include a same material composition.

15. The all-foam mattress assembly of claim 8, wherein the thermoplastic of the deck and the plurality of engineered geometric thermoplastic material profiles include a same material composition.

16. The all-foam mattress assembly of claim 1, wherein each of the plurality of engineered geometric thermoplastic material profiles comprises an arch-shaped thermoplastic profile surrounding a thermoset core of the plurality of thermoset members.

17. The all-foam mattress assembly of claim 2, wherein the plurality of engineered geometric thermoplastic profiles extends from the load distribution member to the deck, the plurality of engineered geometric thermoplastic profiles include a plurality of grooves configured to be orthogonal to the load and configured to gradually close when subjected to the load.

18. The all-foam mattress assembly of claim 17, wherein the plurality of engineered geometric thermoplastic profiles includes at least one spring bore therethrough, the at least one spring bore configured to gradually close when subjected to the load.

19. The all-foam mattress assembly of claim 17, wherein the plurality of grooves each comprises a V-groove shape.

20. The all-foam mattress assembly of claim 2, wherein each of the plurality of engineered geometric thermoplastic material profiles comprises a hollow circular profile secured to and protruding from the load distribution member, the hollow circular profile includes an inner thermoplastic surface forming a hollow passageway and an outer thermoplastic surface surrounding at least one of the plurality of thermoset members.

21. The all-foam mattress assembly of claim 20, wherein each of the hollow circular profiles abuts against the deck.

22. The all-foam mattress assembly of claim 1, wherein each of the plurality of thermoset members are secured to

complementary ones of the plurality of engineered geometric thermoplastic material profiles with an adhesive, cohesive, or thermal bond.

23. The all-foam mattress assembly of claim 1, wherein each of the plurality of thermoset members is secured to complementary ones of the plurality of engineered geometric thermoplastic material profiles with a chemical bond agent.

24. The all-foam mattress assembly of claim 1, wherein each of the plurality of thermoset members is secured to complementary ones of the plurality of engineered geometric thermoplastic material profiles with a stratum.

25. The all-foam mattress assembly of claim 24, wherein the stratum includes a chemical bond agent.

26. The all-foam mattress assembly of claim 25, wherein the chemical bond agent comprises N-(2-aminoethyl)-3-aminopropyltrimethoxysilane.

27. An all-foam mattress assembly, comprising:

at least one foam comfort layer to receive a load of a user; at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and

a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck,

wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck, and

wherein, collectively, an unloaded density of the at least one foam comfort layer, the at least one foam transitional layer, and the foam engineered core comprise a density between 0.8 pounds per cubic foot and 3.0 pounds per cubic foot.

28. The all-foam mattress assembly of claim 27, wherein an unloaded density of the plurality of engineered geometric thermoplastic material profiles is greater than 1.3 pounds per cubic foot and less than 1.7 pounds per cubic foot.

29. The all-foam mattress assembly of claim 27, wherein an unloaded density of the plurality of thermoset members is greater than 1.7 pounds per cubic foot and less than 2.5 pounds per cubic foot.

30. The all-foam mattress assembly of claim 28, wherein, while unburdened by the load, the foam engineered core comprises at least 25 percent thermoplastic by volume, at least 25 percent of at least one thermoset material by volume, and at least 25 percent bulk-free volume.

31. An all-foam mattress assembly, comprising:

at least one foam comfort layer to receive a load of a user; at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and

a foam engineered core being less dense than the at least one foam transitional layer, the foam engineered core comprises a plurality of engineered geometric thermoplastic material profiles, bulk-free volume, a deck, and plurality of thermoset members collectively configured with the plurality of engineered geometric thermoplastic

material profiles to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck.

32. The all-foam mattress assembly of claim 31, wherein each of the plurality of engineered geometric thermoplastic material profiles at least partially surrounds at least a portion of the bulk-free volume.

33. The all-foam mattress assembly of claim 31, wherein the foam engineered core further comprises a portion of the bulk-free volume between adjacent members of the plurality of engineered geometric thermoplastic material profiles.

34. The all-foam mattress assembly of claim 31, wherein the foam engineered core abuts against the at least one foam transitional layer.

35. The all-foam mattress assembly of claim 31, wherein the deck includes at least one channel configured to be orthogonal to the load.

36. An all-foam mattress assembly, comprising:

at least one foam comfort layer to receive a load of a user; at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and

a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck,

wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer and to convey the load to the deck, and

wherein the foam engineered core comprises between fifteen (15) percent and fifty (50) percent bulk-free volume, and the foam engineered core is configured to support the load through the at least one foam comfort layer and the at least one transitional layer.

37. The all-foam mattress assembly of claim 36, wherein the foam engineered core, when free of the load, comprises at least 25 percent thermoplastic by volume, at least 25 percent thermoset by volume, and at least 25 percent bulk-free volume.

38. The all-foam mattress assembly of claim 36, wherein the foam engineered core, the at least one transitional layer, and the at least one foam comfort layer, collectively and free of the load, comprise at least 25 percent bulk-free volume.

39. An all-foam mattress assembly, comprising:

at least one foam comfort layer to receive a load of a user; at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and

a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, and a deck,

wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset mem-

bers are collectively configured to receive the load conveyed from the at least one transitional layer and to convey the load to the deck, and

wherein the foam engineered core includes bulk-free volume.

40. The all-foam mattress assembly of claim 39, wherein the foam engineered core abuts against the at least one foam transitional layer.

41. The all-foam mattress assembly of claim 40, wherein each of the plurality of engineered geometric thermoplastic material profiles comprises a hollow circular profile secured to and protruding from a load distribution member, the hollow circular profile includes an inner thermoplastic surface forming a hollow passageway and an outer thermoplastic surface surrounding at least one of the plurality of thermoset members.

42. The all-foam mattress assembly of claim 41, wherein each of the hollow circular profiles abuts against the deck.

43. An all-foam mattress assembly, comprising:

at least one foam comfort layer to receive a load of a user; at least one foam transitional layer receiving the load from the at least one foam comfort layer, the at least one foam transitional layer having a density more than a density of the at least one foam comfort layer; and

a foam engineered core comprising a plurality of engineered geometric thermoplastic material profiles disposed in a parallel arrangement, a plurality of thermoset members disposed in the parallel arrangement and adjacent to the plurality of engineered geometric thermoplastic material profiles, a load allocation member, and a deck,

wherein the plurality of engineered geometric thermoplastic material profiles and the plurality of thermoset members are collectively configured to receive the load conveyed from the at least one foam transitional layer via the load allocation member and to convey the load to the deck,

wherein a strain of a combined height of the load allocation member, plurality of engineered geometric thermoplastic material profiles, and the plurality of thermoset members have a stress-strain relationship represented by Y being less than or equal to $0.012143 * X^4 - 0.7467 * X^3 + 10.03761 * X^2 + 346.196 * X - 123.5391$,

wherein X being strain measured in percent of the foam engineered core, and Y being a corresponding stress in pascals for values of X between 15 to 42 percent.

44. The all-foam mattress assembly of claim 43, wherein the stress-strain relationship represented by Y being greater than or equal to $0.0029545 * X^4 - 0.187879 * X^3 + 2.174242 * X^2 + 98.9177 * X + 11.4719$ for values of X between 15 to 42 percent.

45. The all-foam mattress assembly of claim 44, wherein the stress-strain relationship represented by Y being greater than or equal to $0.0029924 * X^4 - 0.1118687 * X^3 + 0.5568182 * X^2 + 171.3276 * X + 44.3723$ for values of X between 15 to 42 percent.

46. The all-foam mattress assembly of claim 44, wherein the stress-strain relationship represented by Y being less than or equal to $0.0013636 * X^4 + 0.13636 * X^3 - 7.06061 * X^2 + 273.182 * X - 39.3939$ for values of X between 15 to 42 percent.

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