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(54) **PERSONAL PROTECTIVE VEST ASSEMBLY  
AND METHODS OF ASSEMBLING SAME**

(71) Applicant: **Safe Life Defense, LLC**, Henderson, NV (US)

(72) Inventor: **Nick Groat**, Henderson, NV (US)

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**F41H 1/02**

(2006.01)

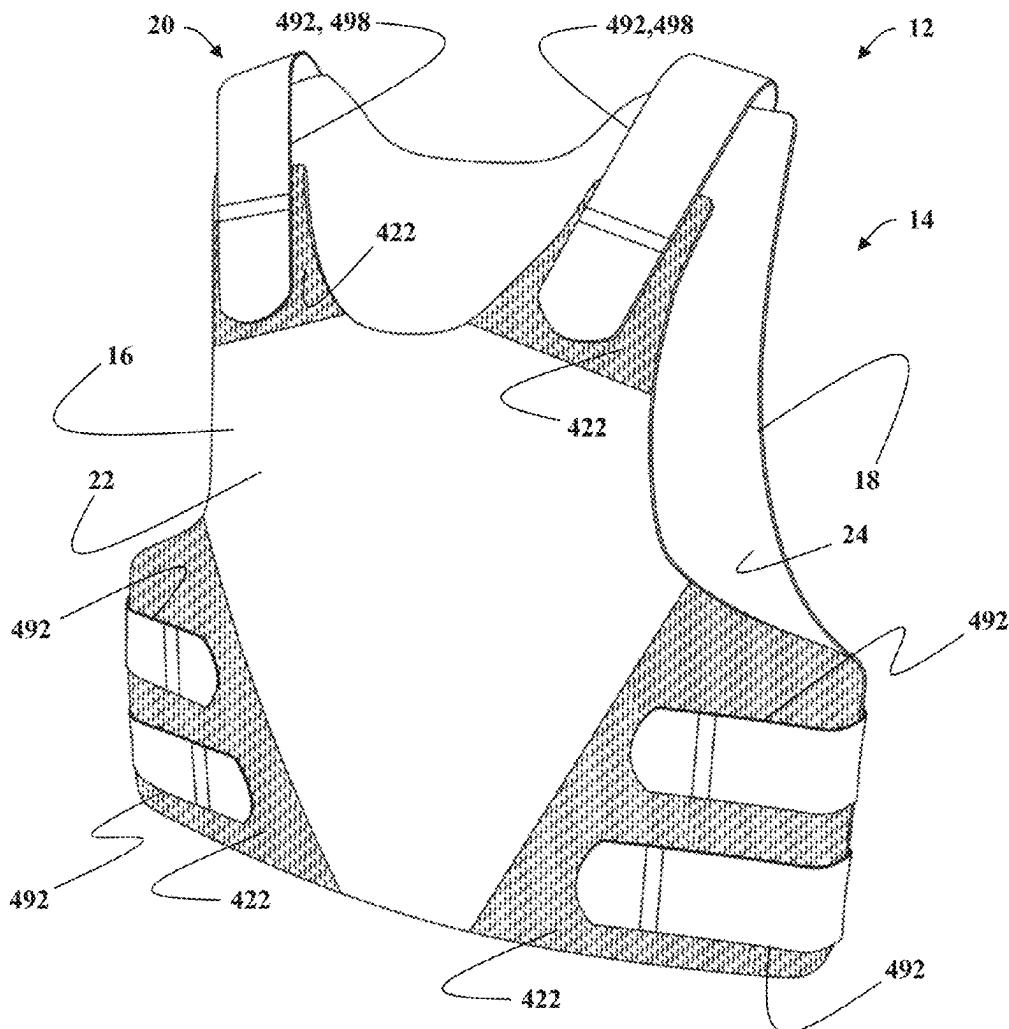
(52) **U.S. Cl.**

CPC ..... **F41H 1/02** (2013.01)

(57) **ABSTRACT**

A personal protective vest assembly is described herein. The personal protective vest assembly includes a carrier vest including a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis.

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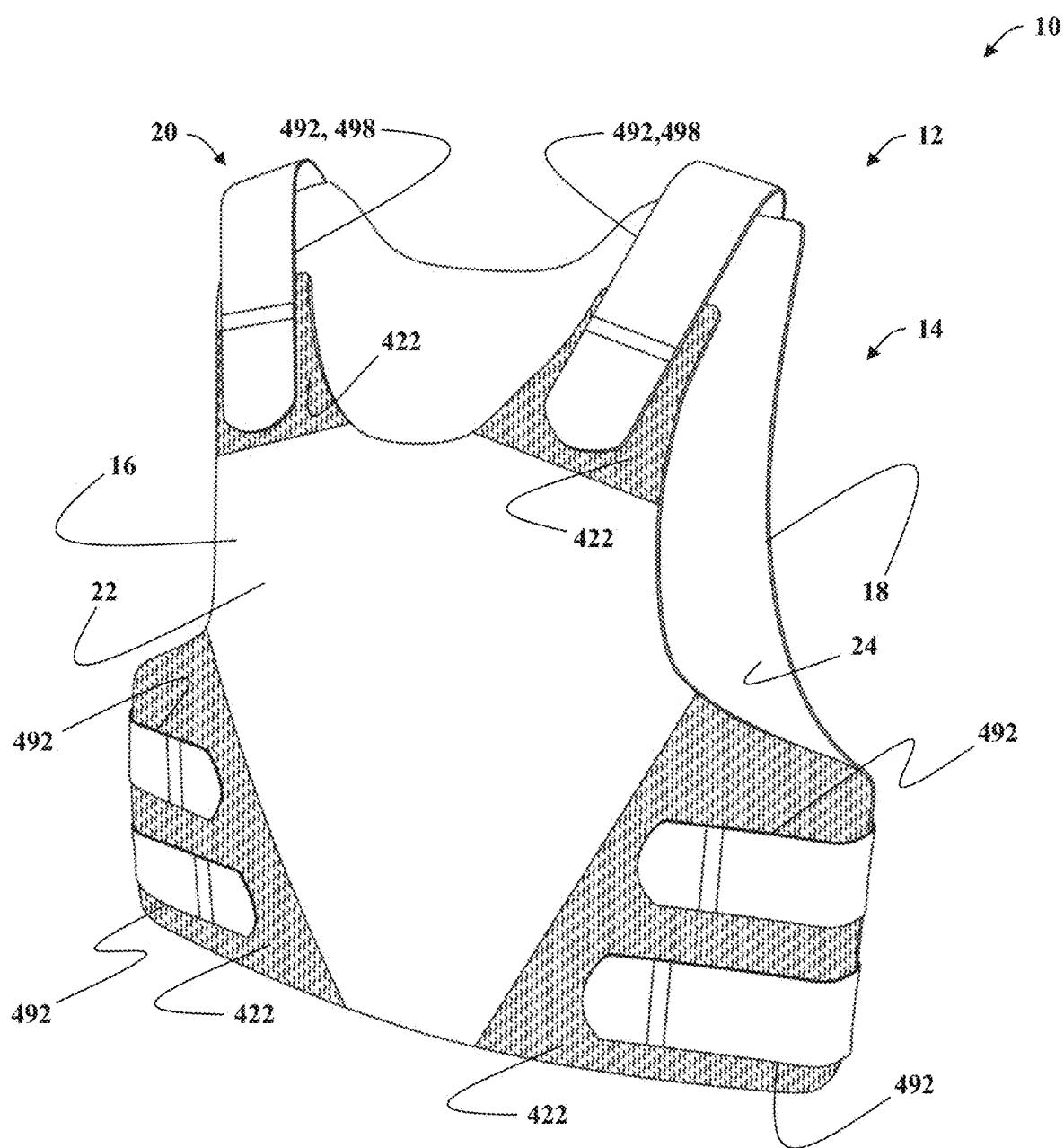
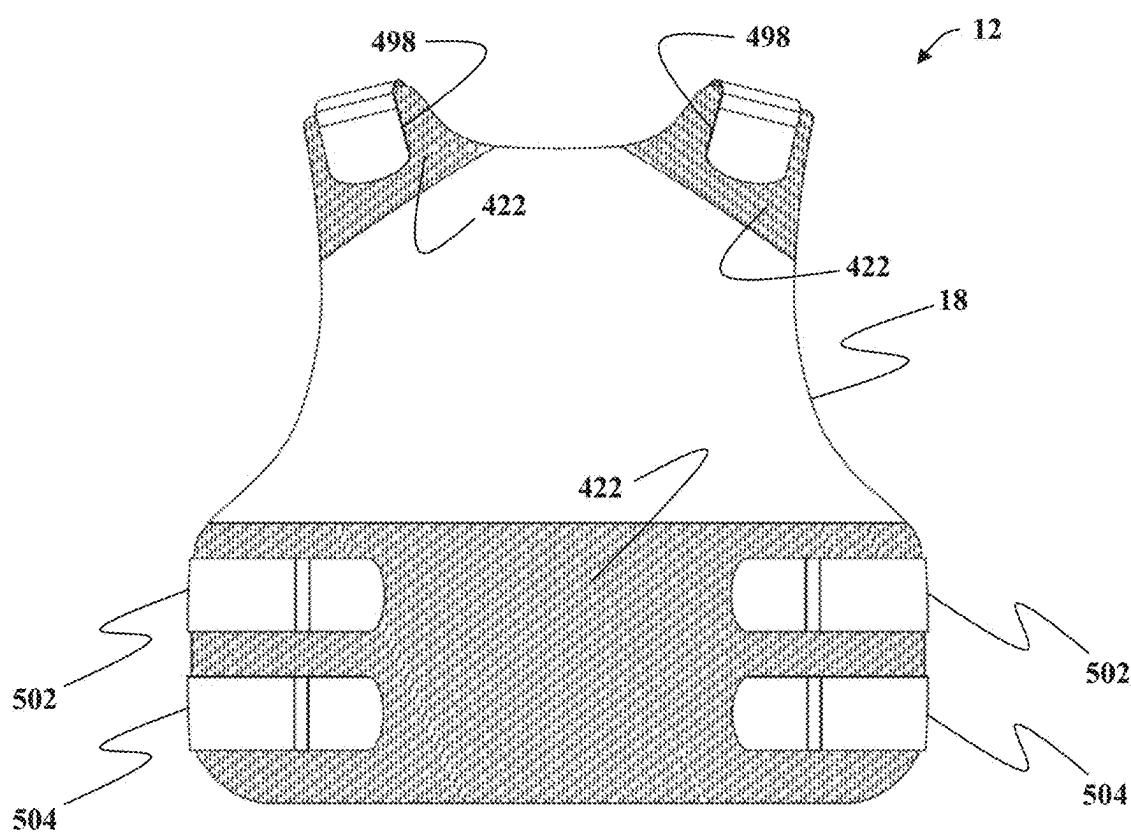
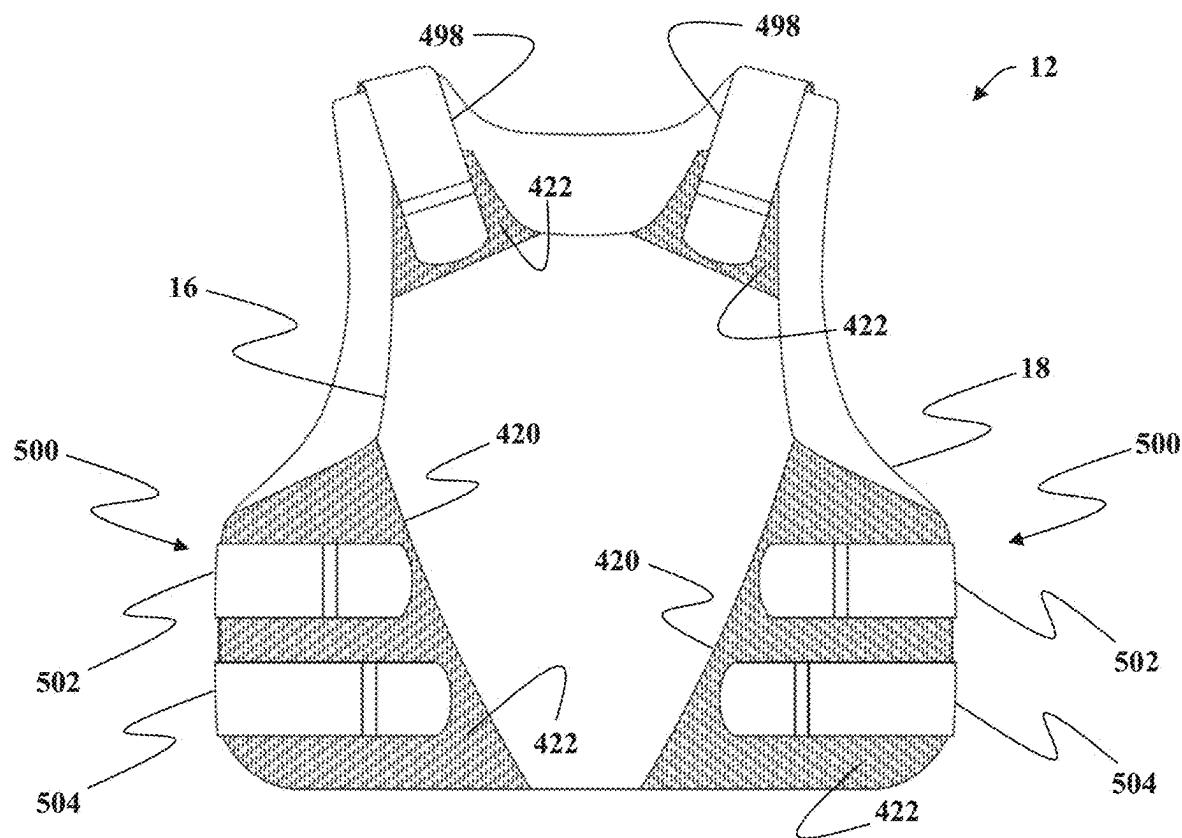
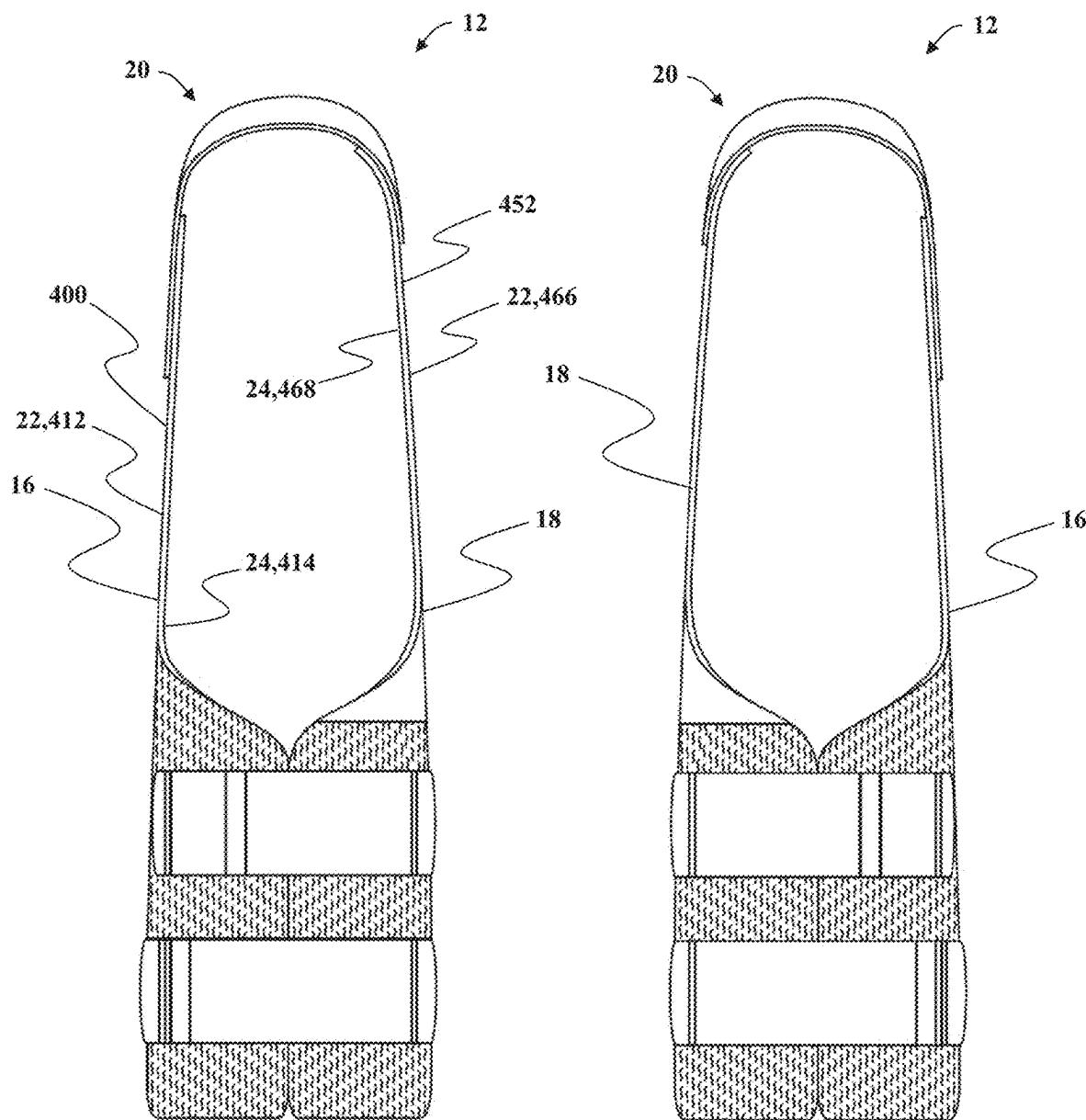


FIG. 1





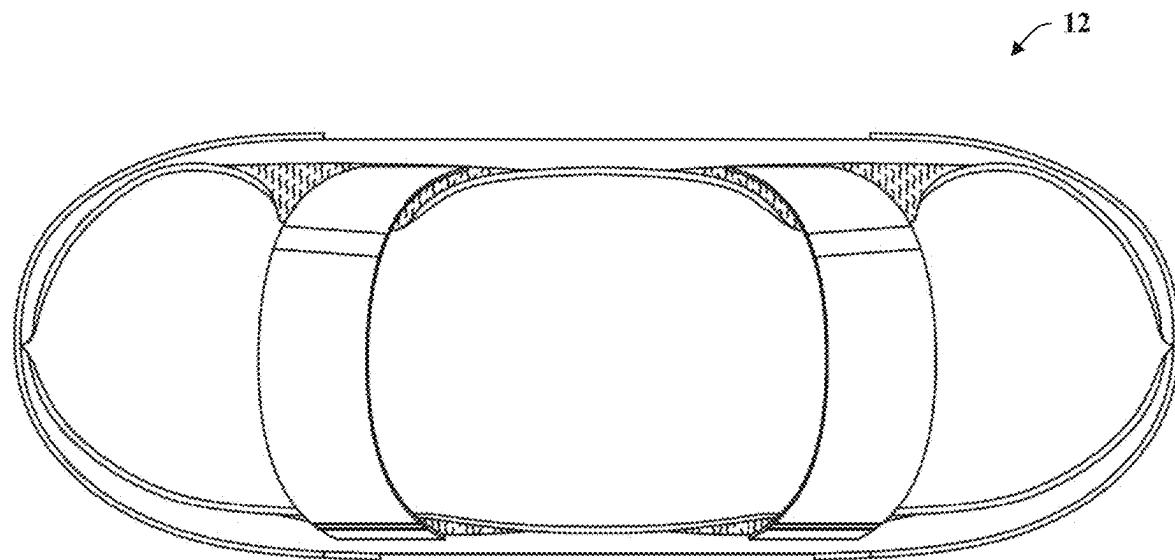


FIG. 6

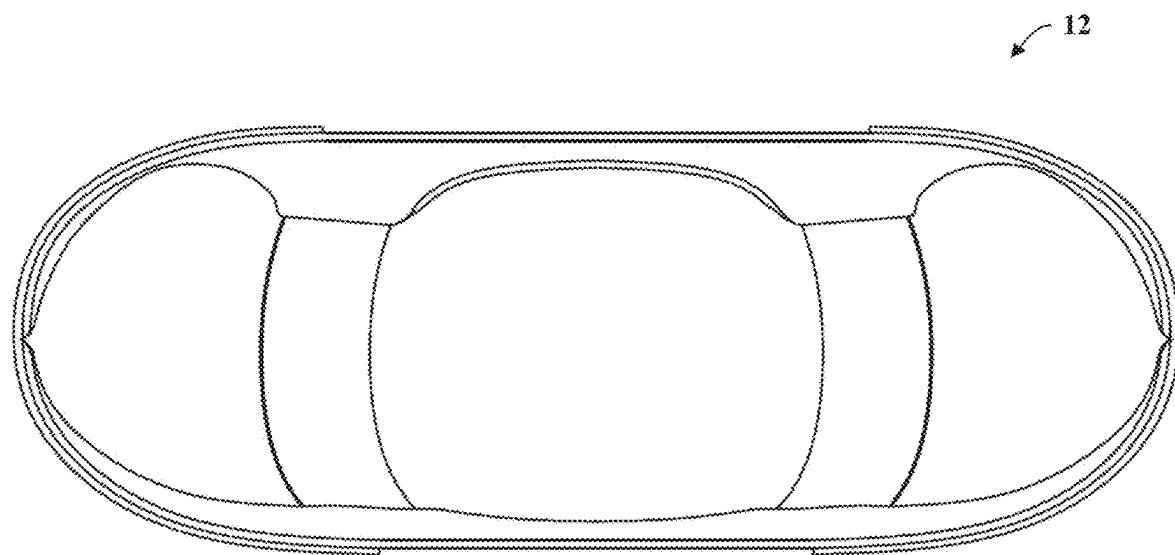


FIG. 7

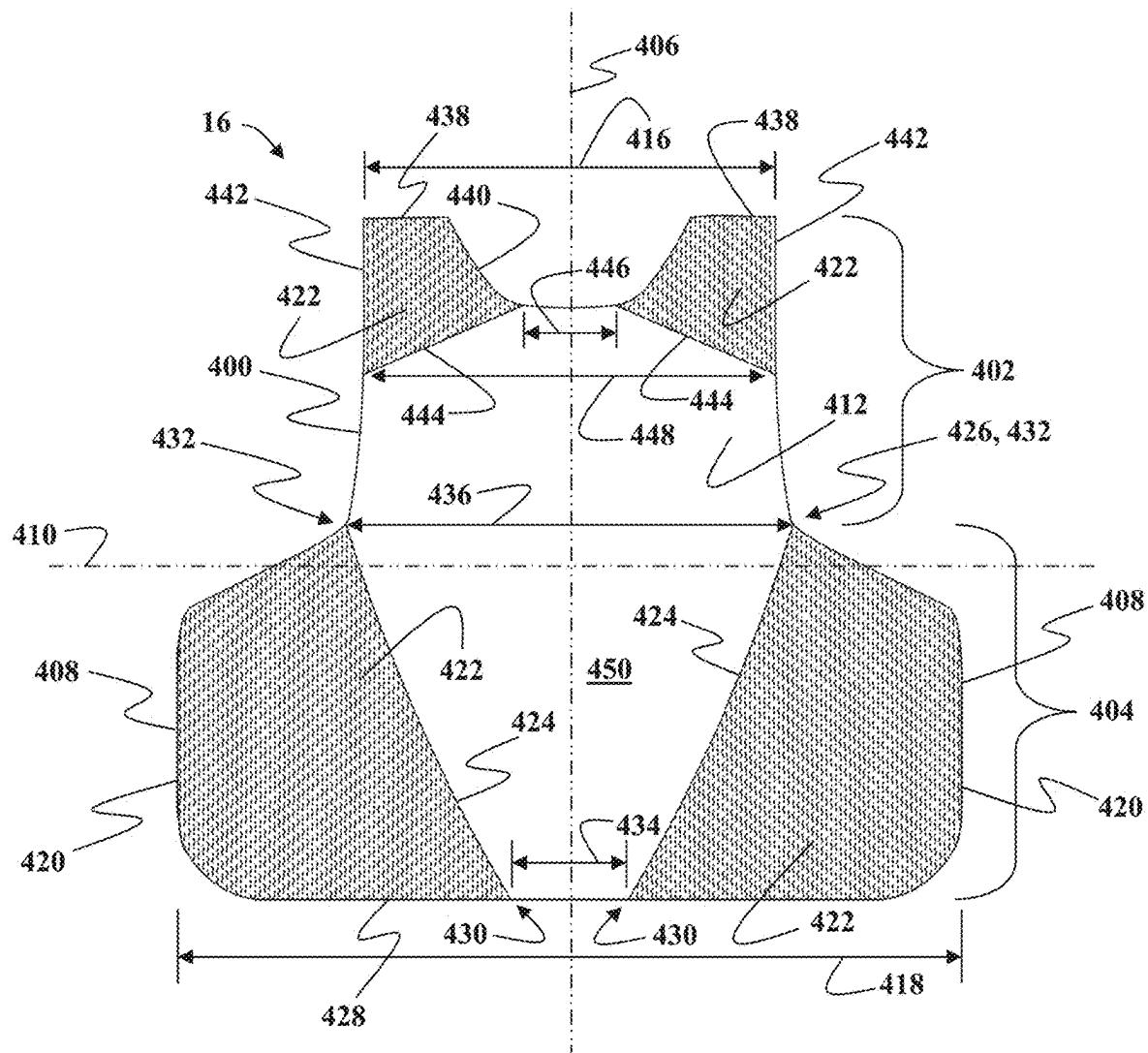


FIG. 8

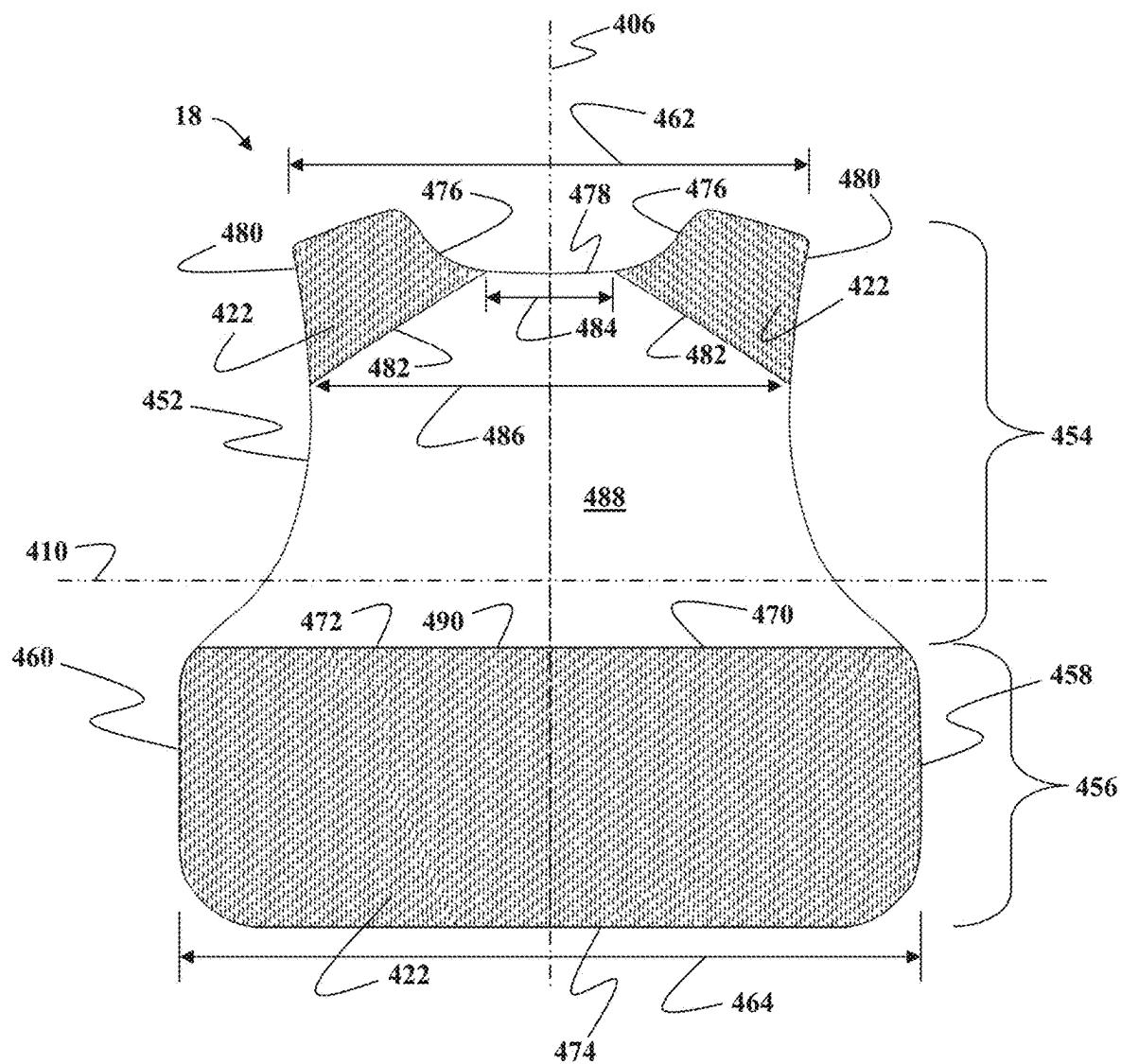


FIG. 9

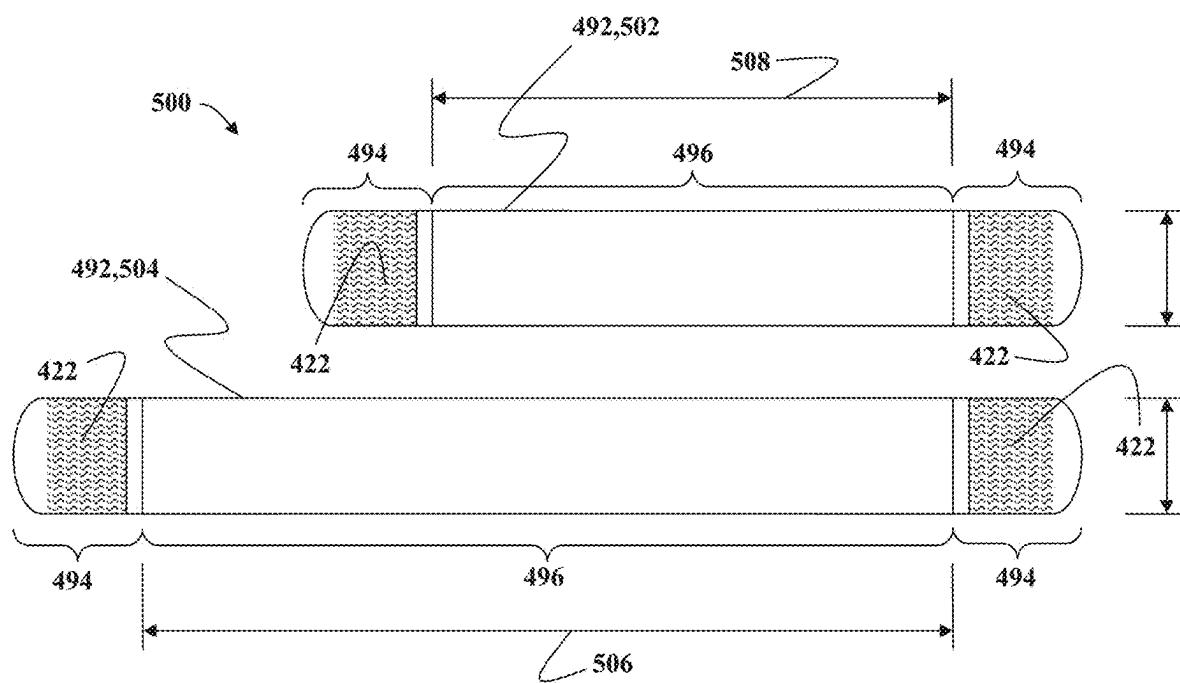


FIG. 10

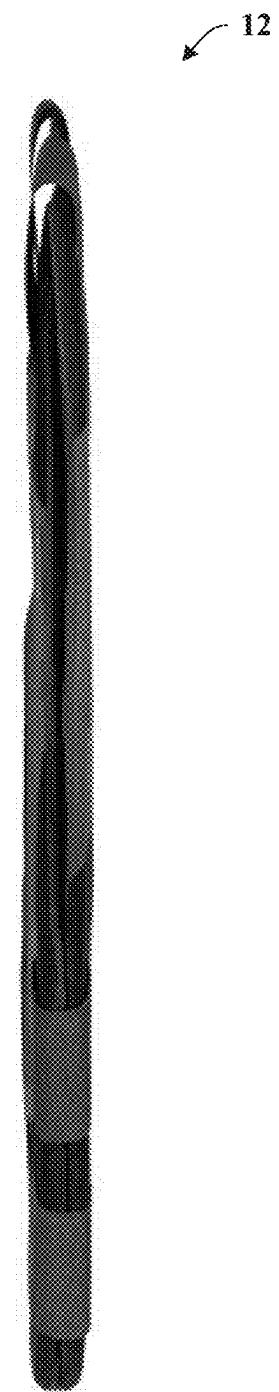


FIG. 11



FIG. 12



FIG. 13

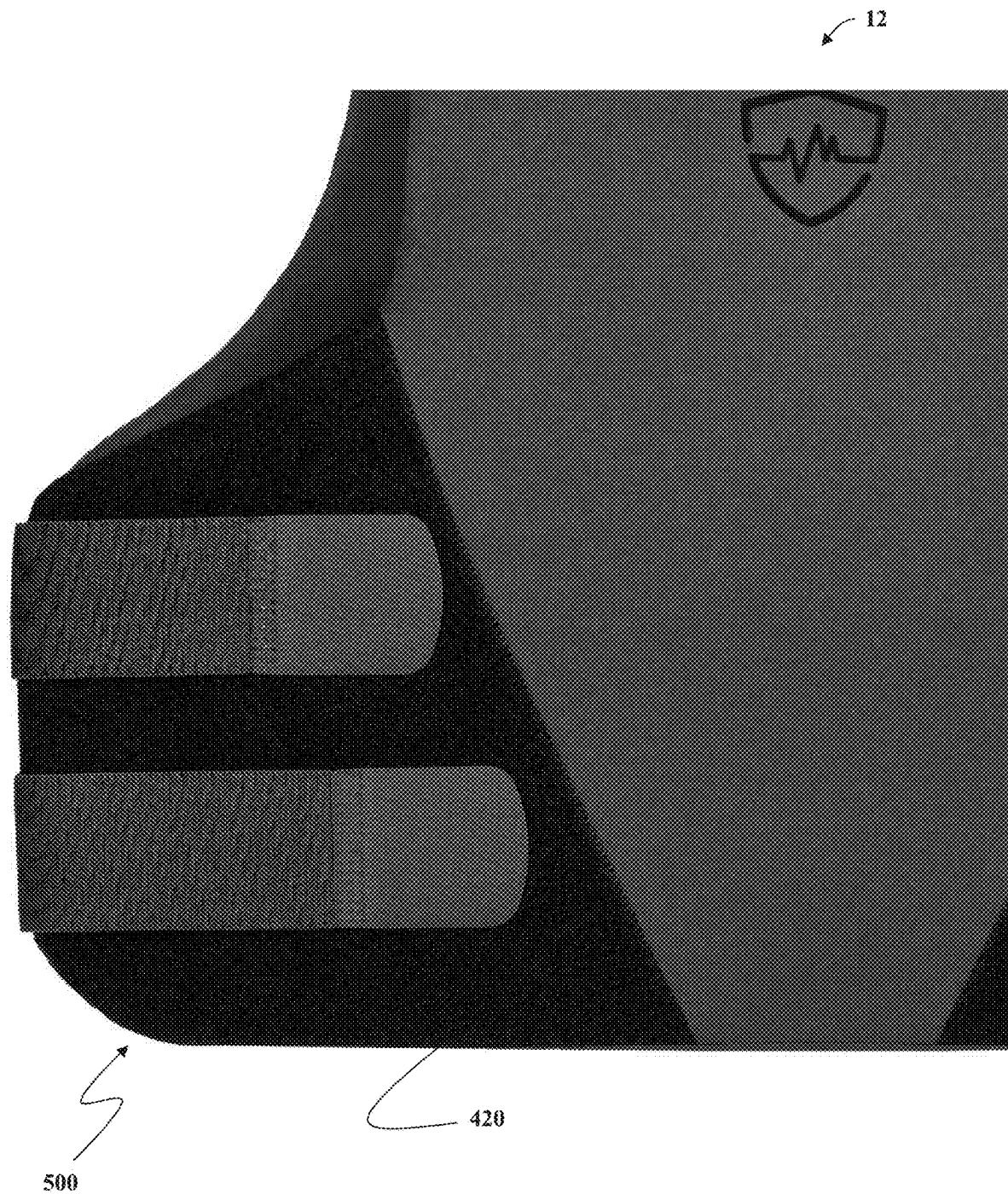


FIG. 14



FIG. 15



FIG. 16



FIG. 17

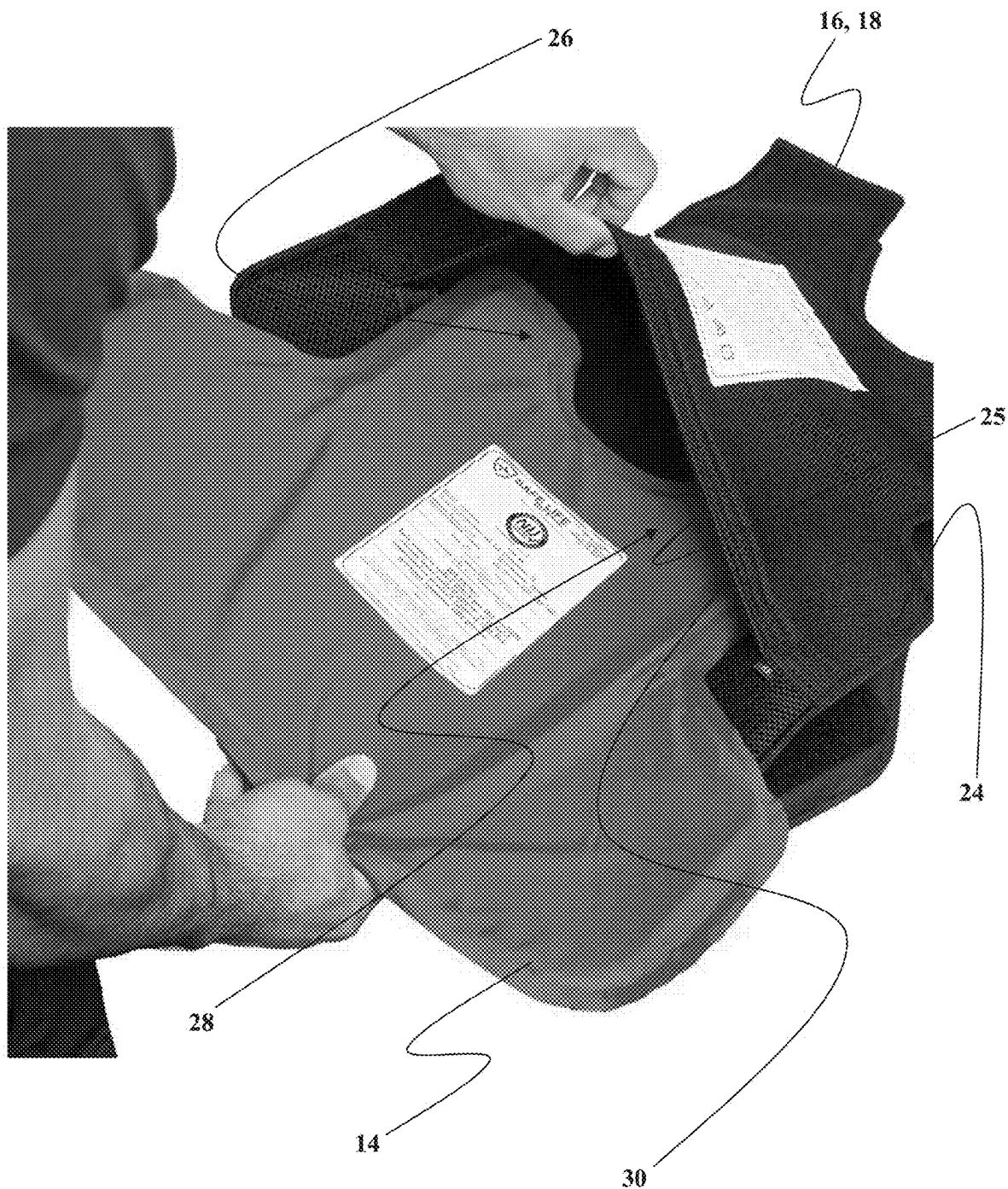


FIG. 18

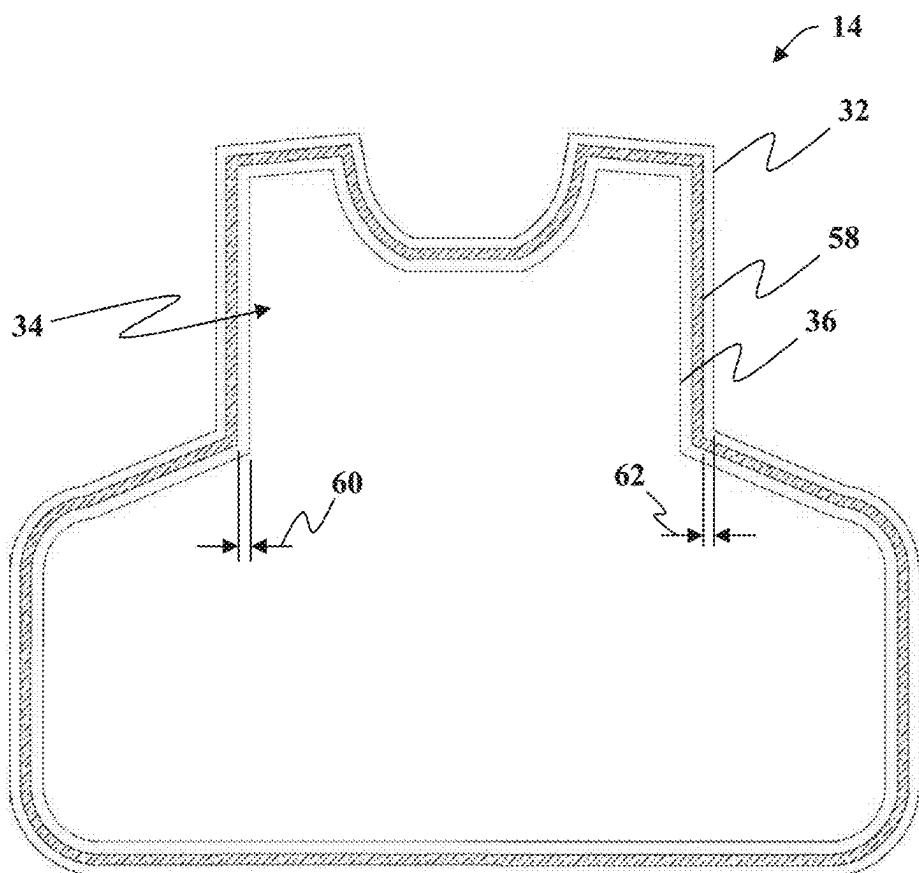


FIG. 19

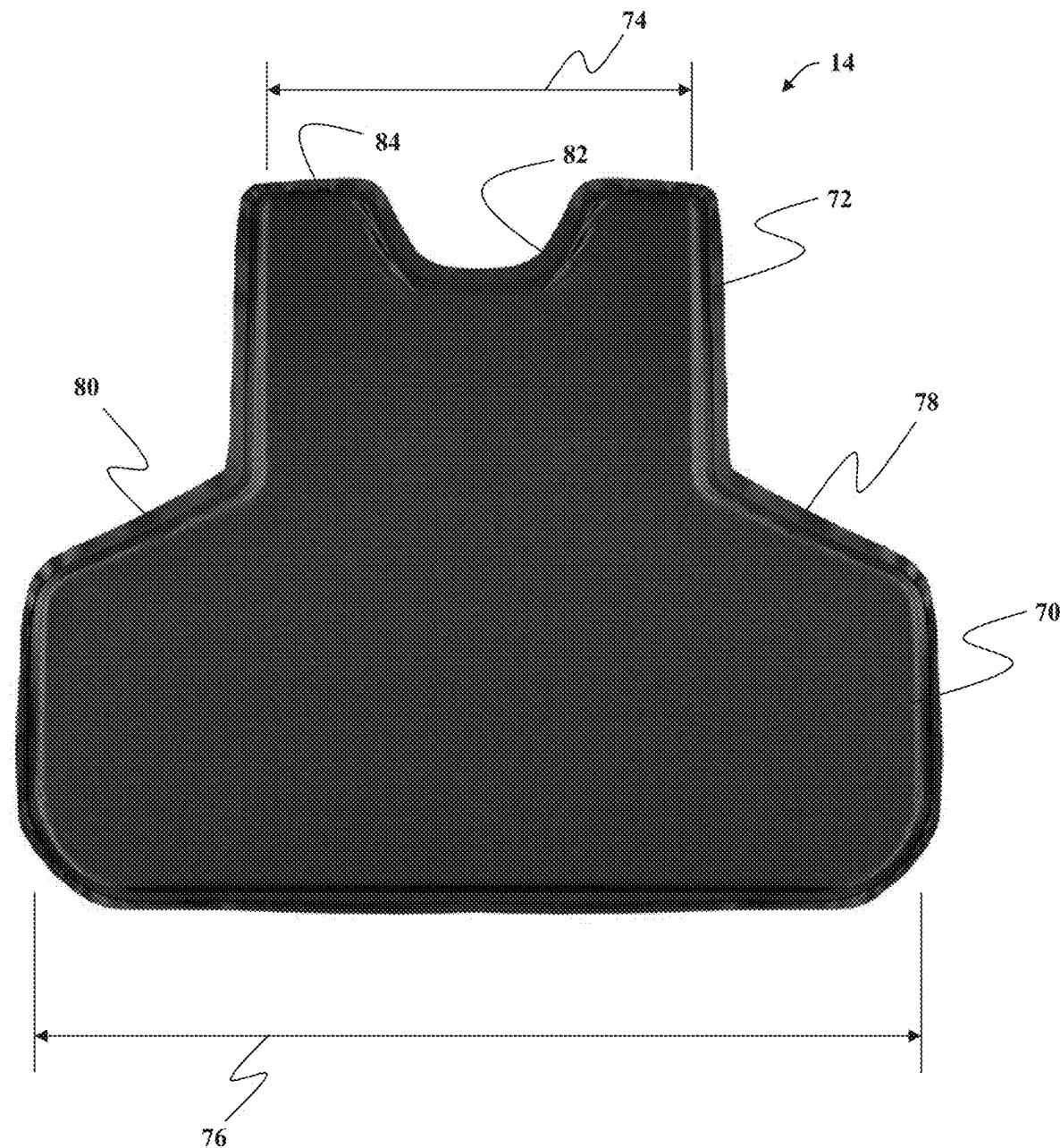


FIG. 20

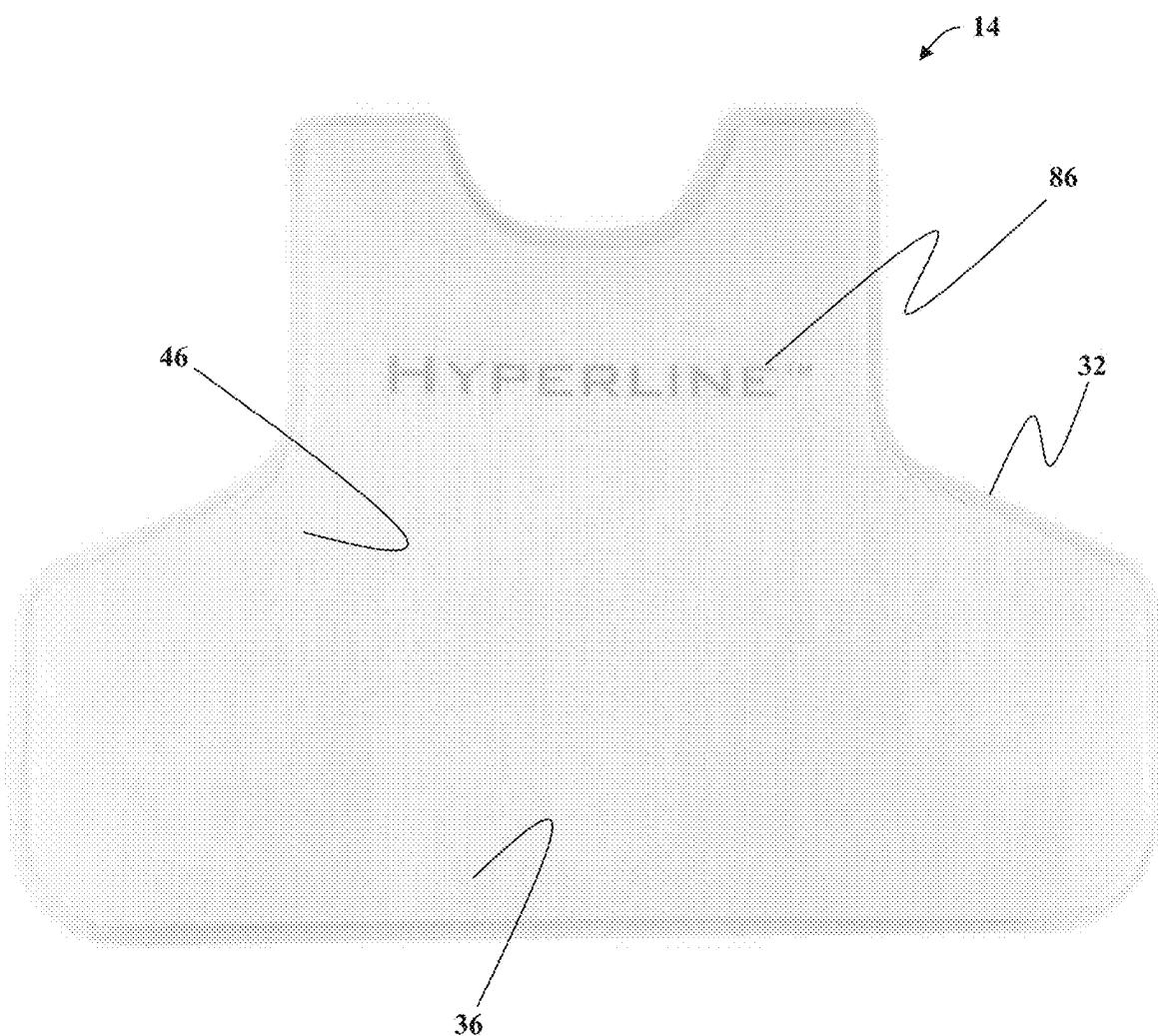


FIG. 21

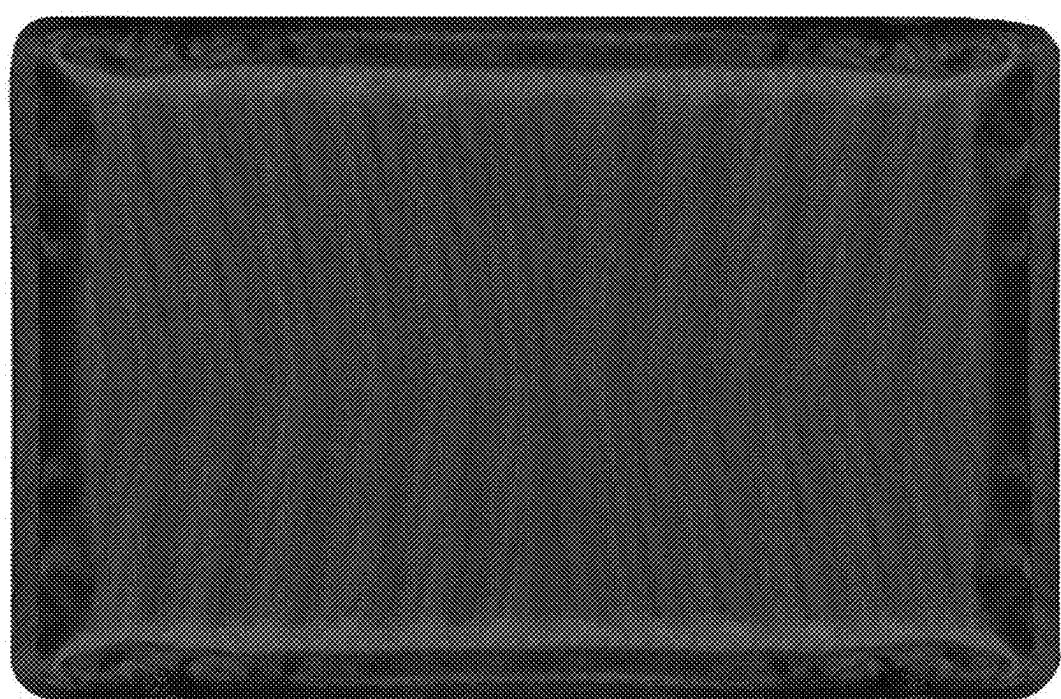


FIG. 22

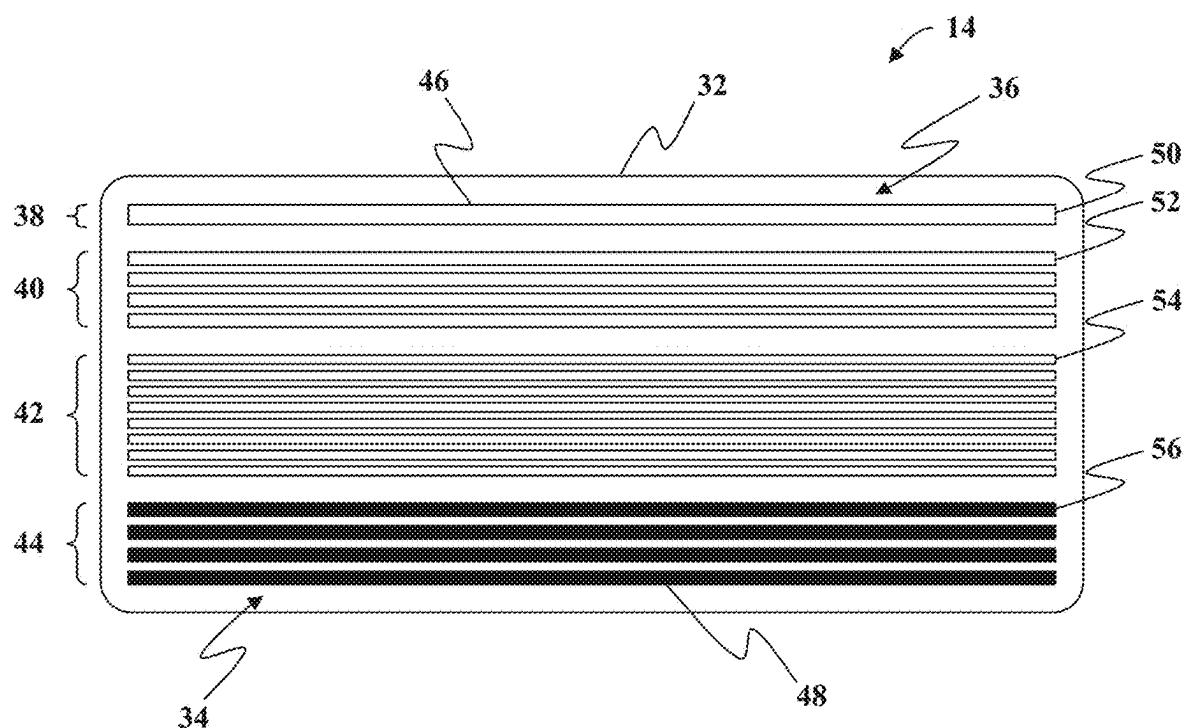


FIG. 23

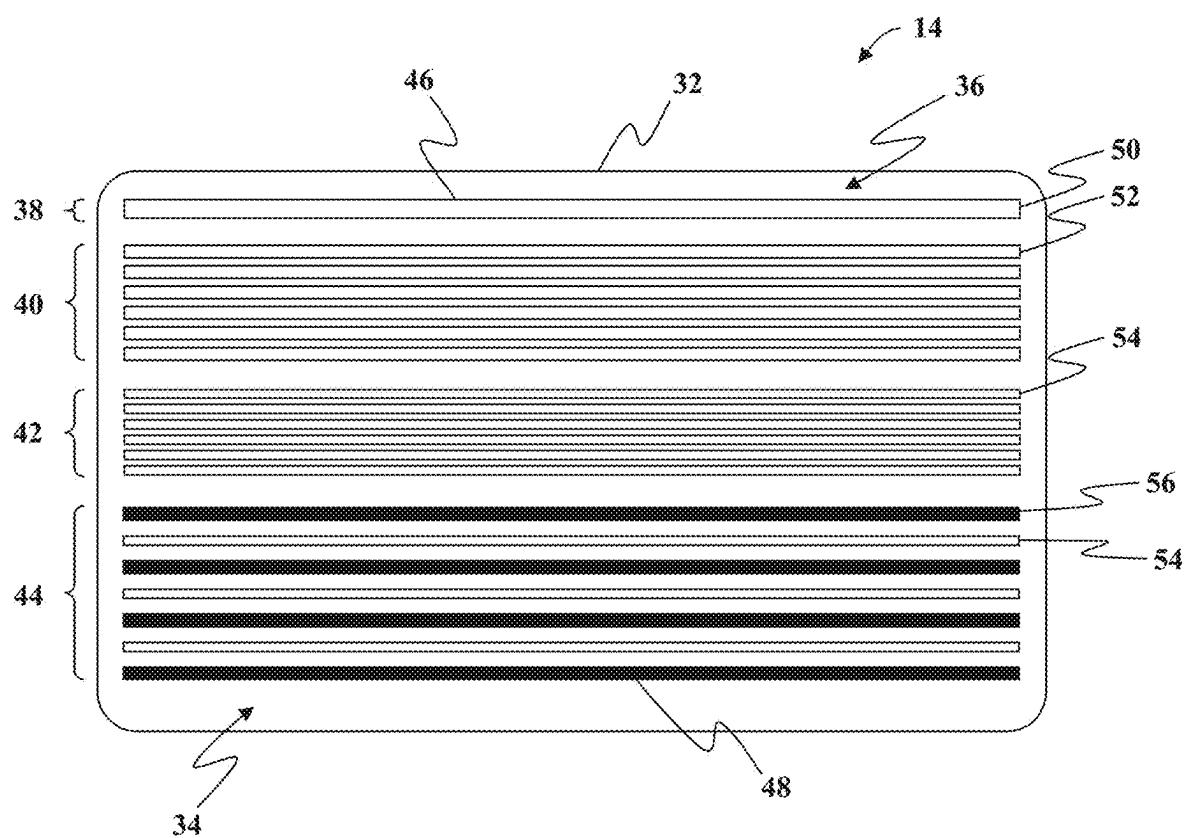


FIG. 24

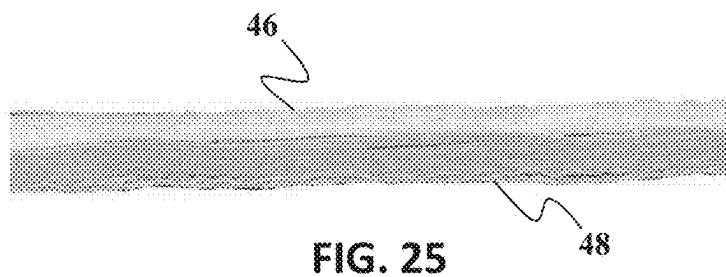


FIG. 25

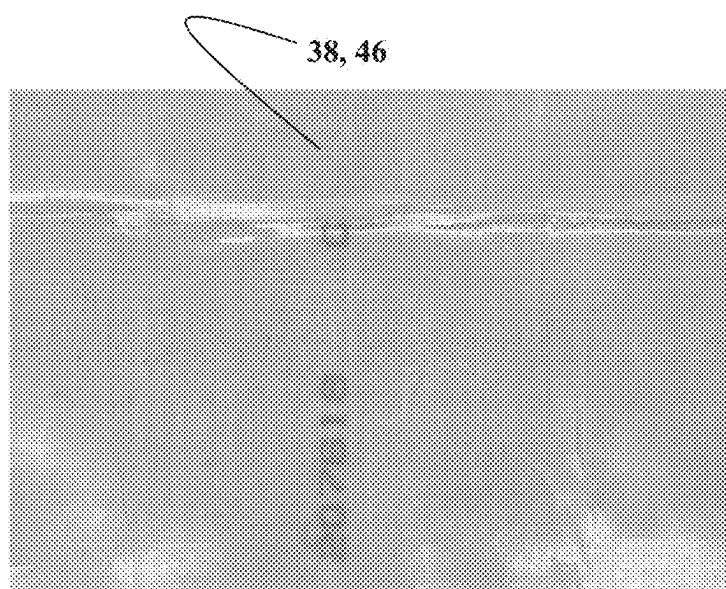


FIG. 26

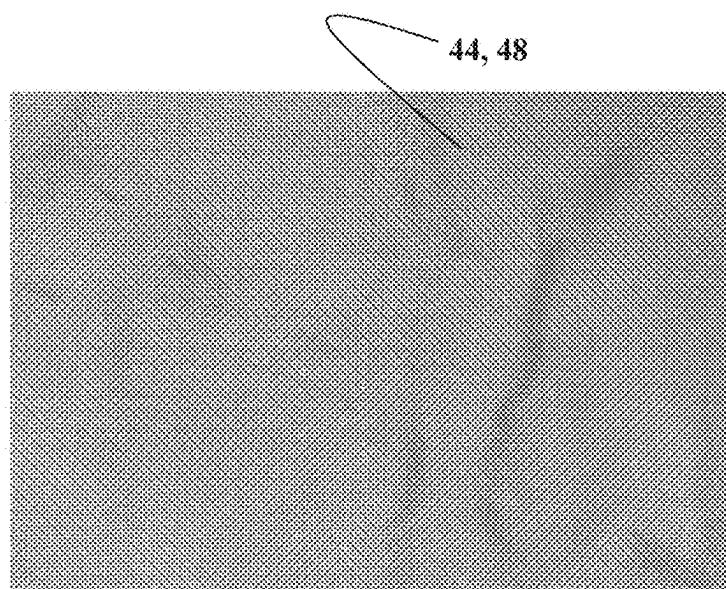


FIG. 27

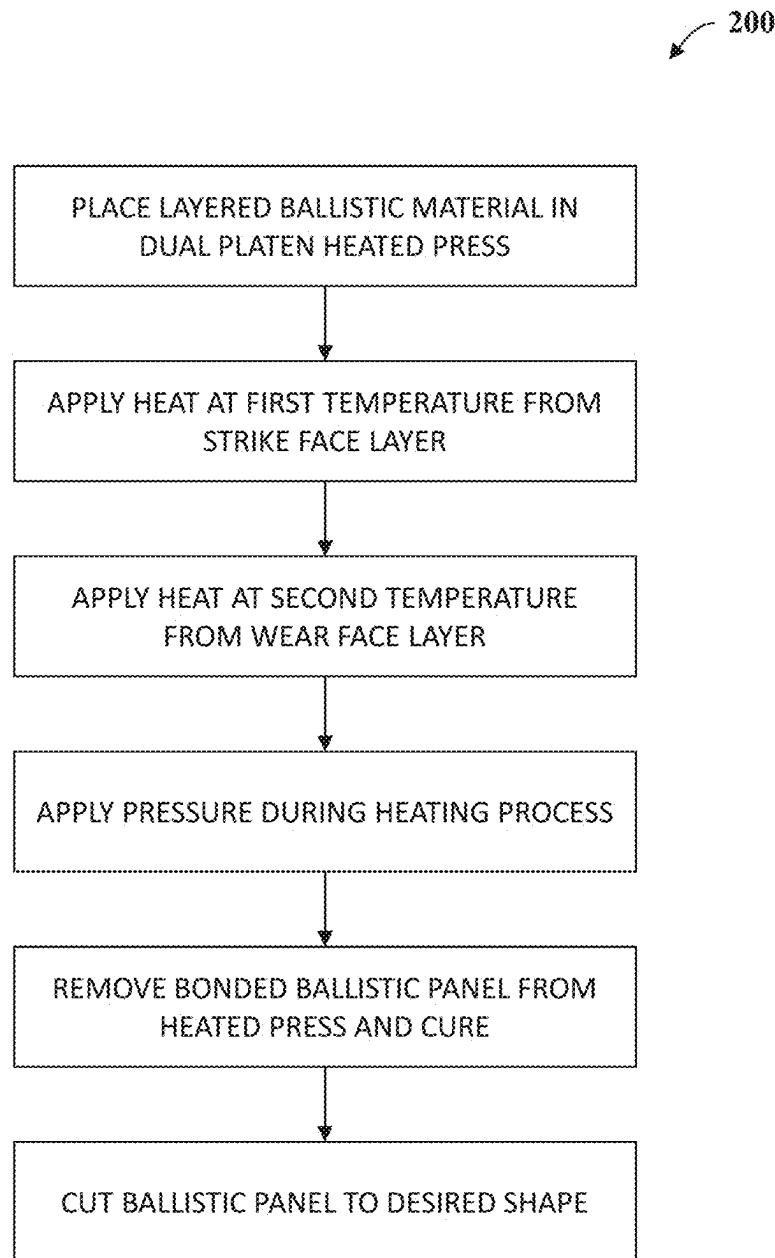


FIG. 28

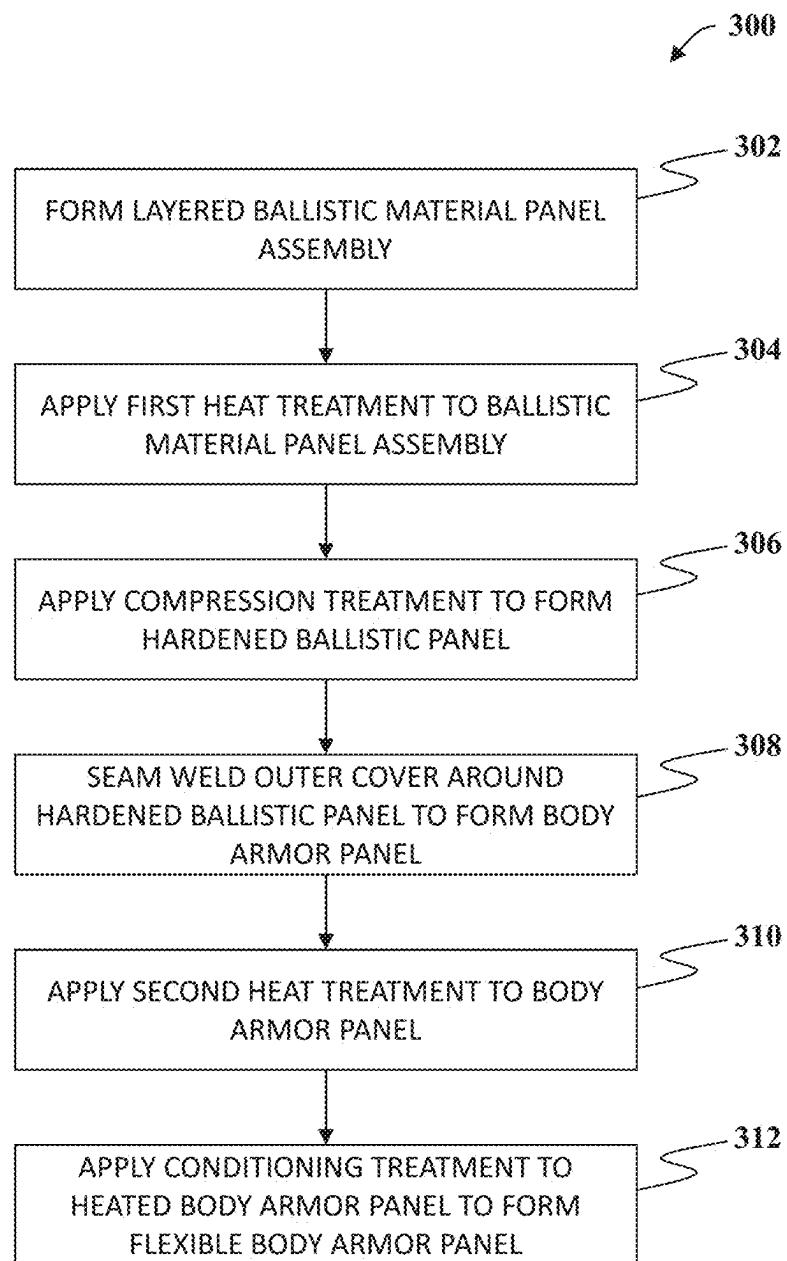


FIG. 29

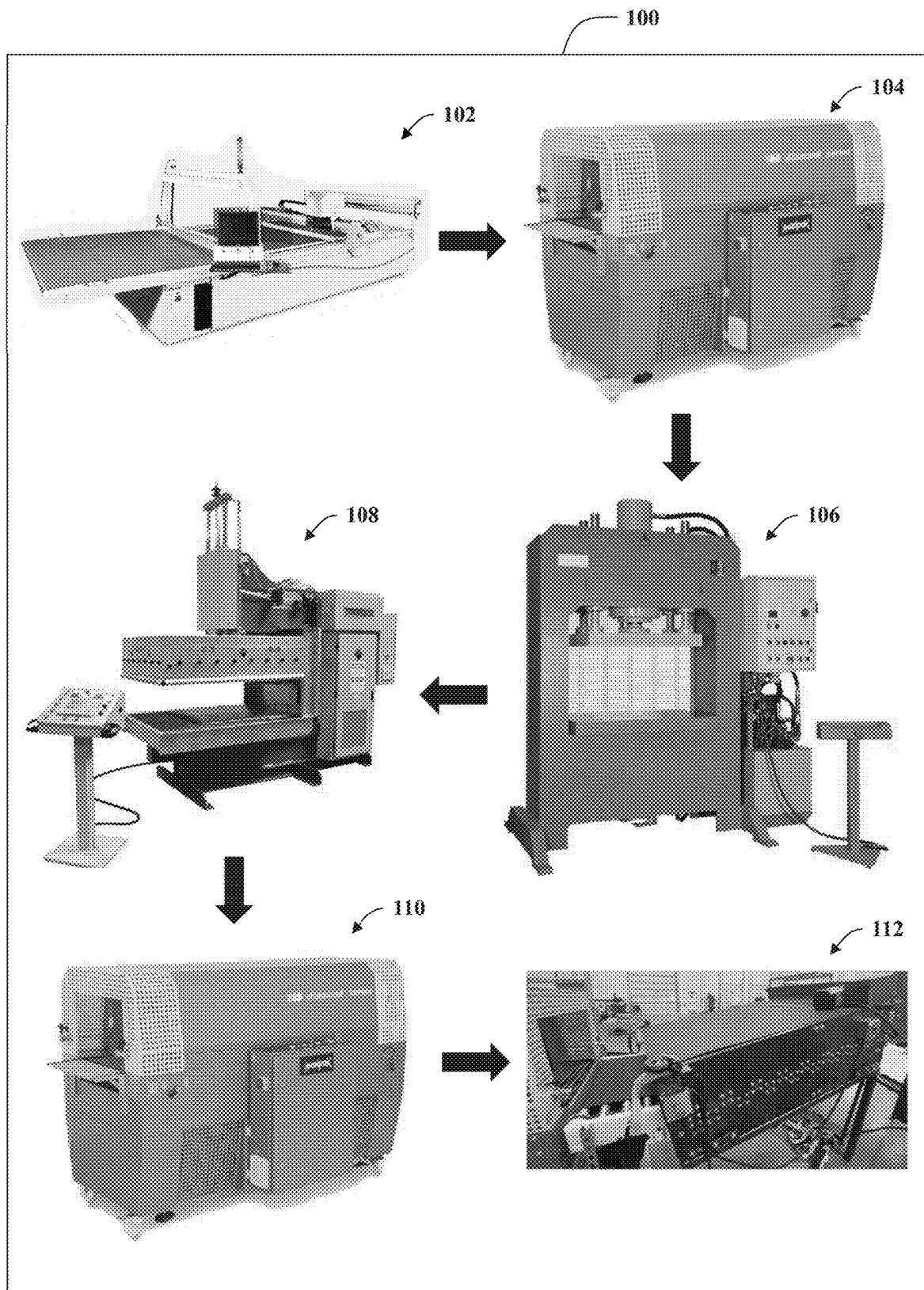


FIG. 30

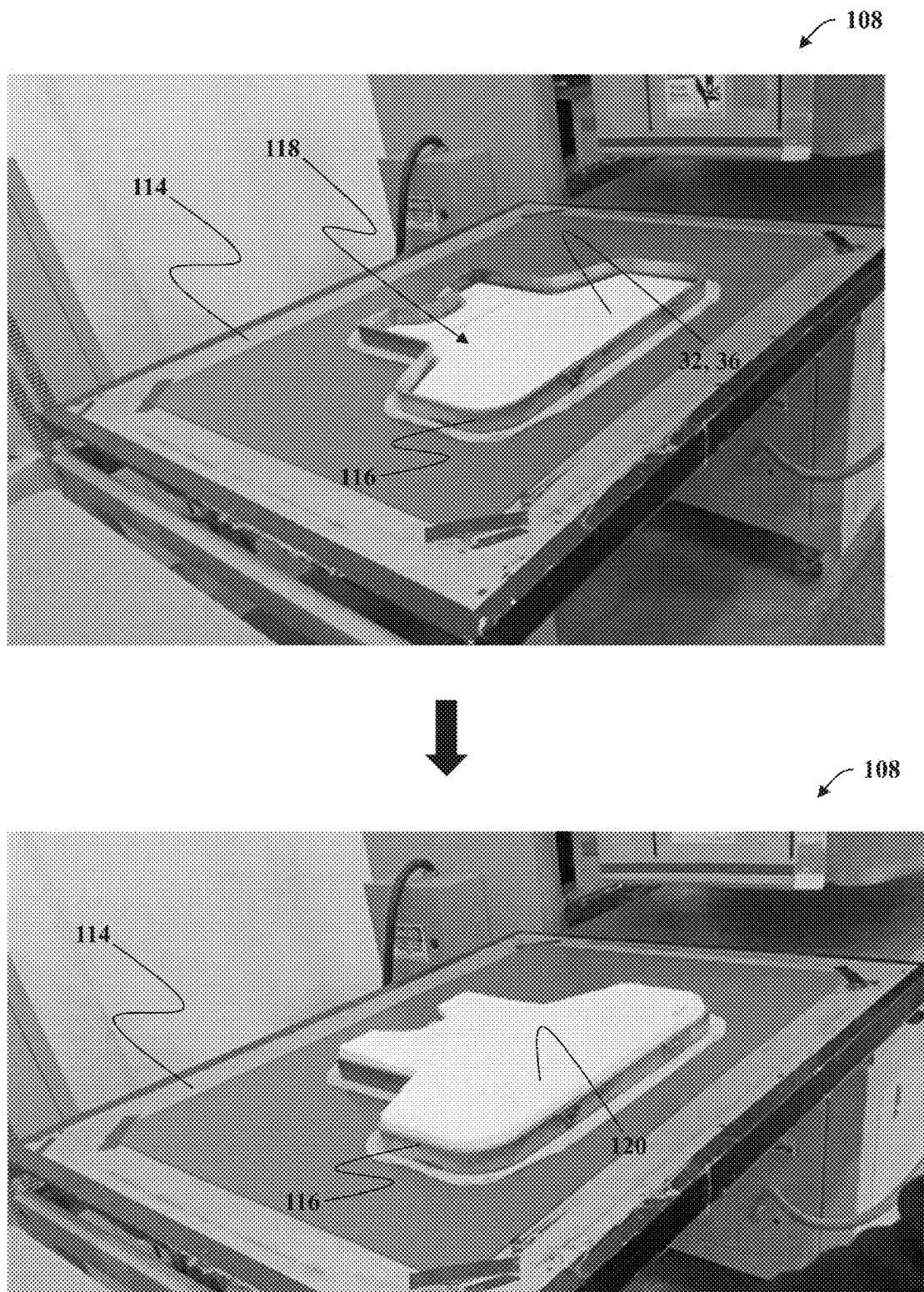


FIG. 31

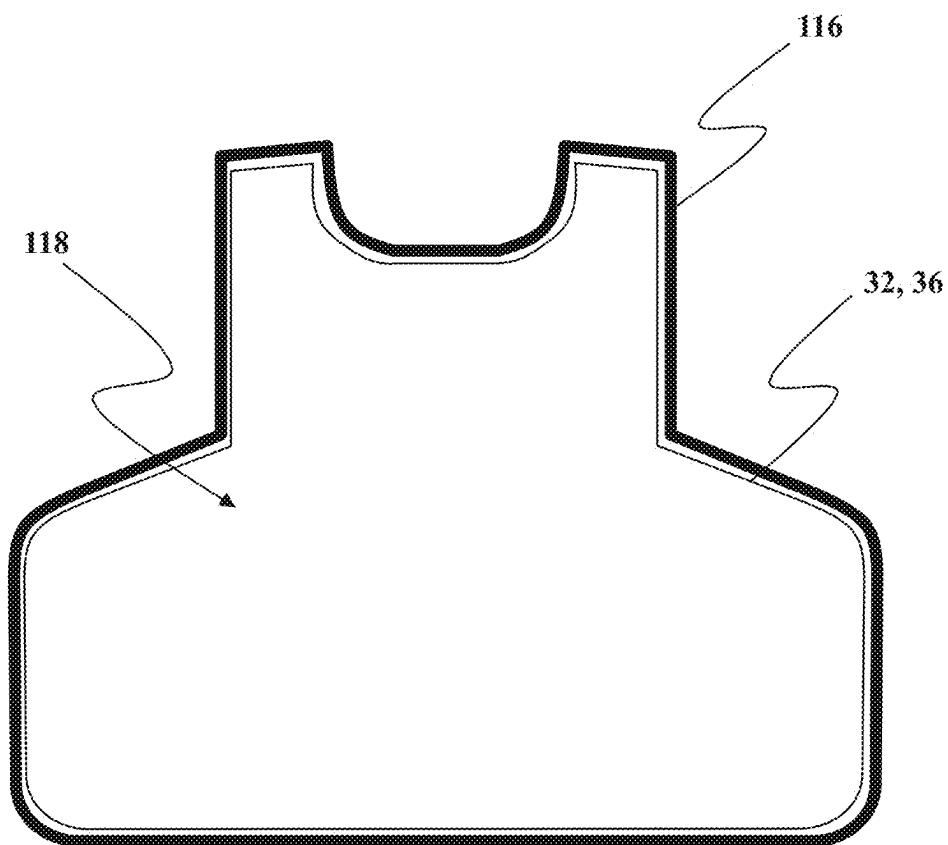


FIG. 32

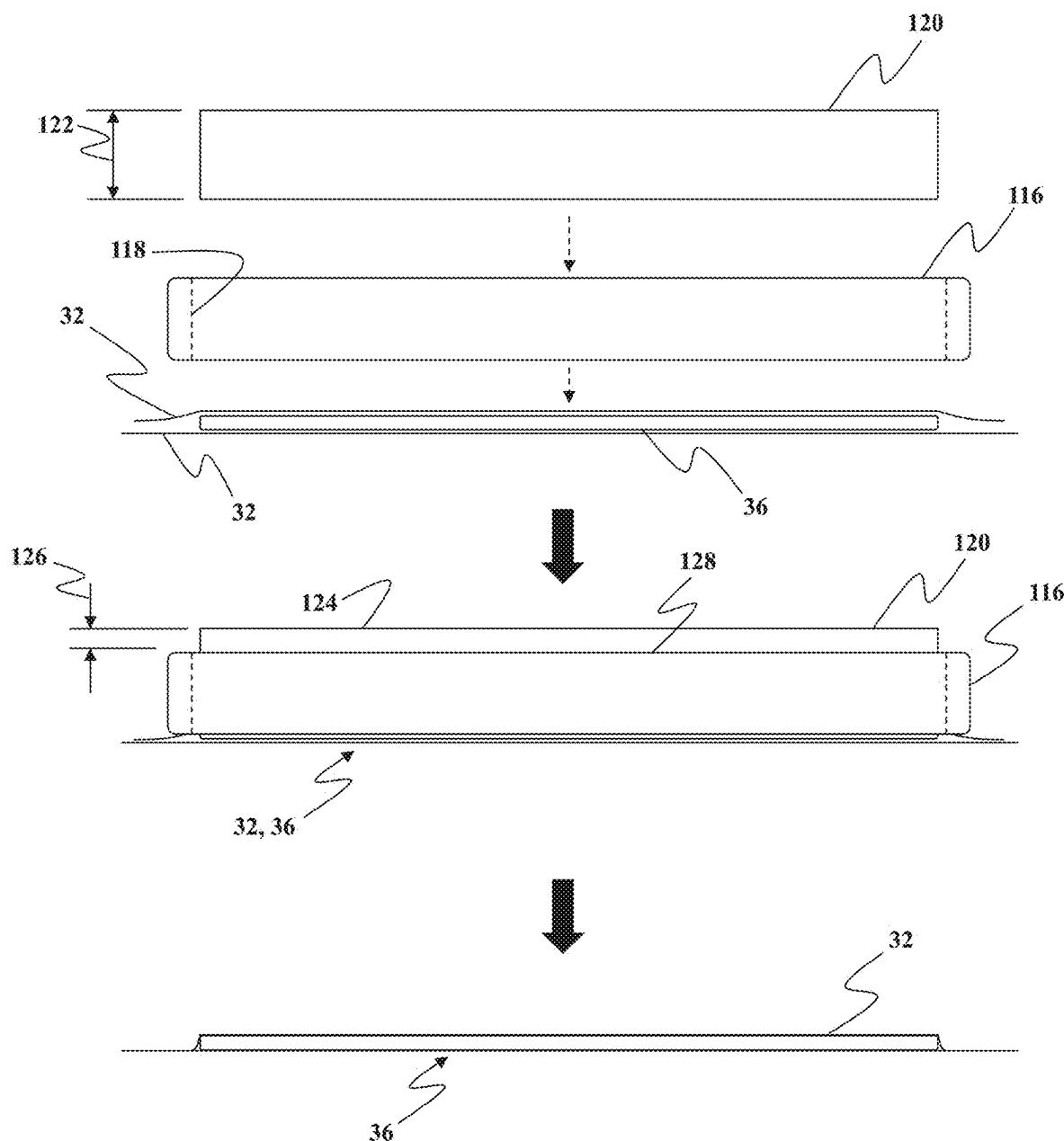


FIG. 33

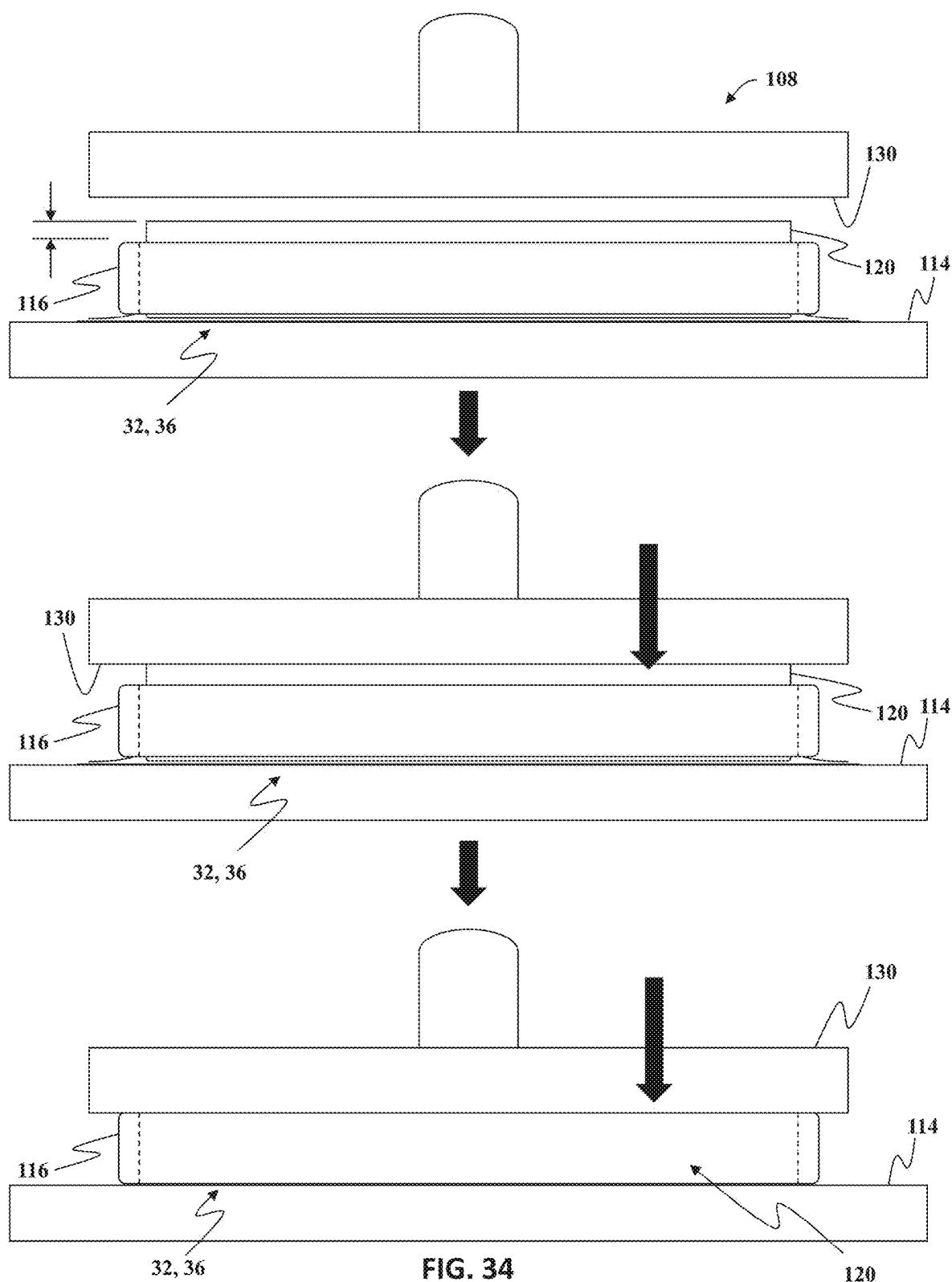


FIG. 34

## PERSONAL PROTECTIVE VEST ASSEMBLY AND METHODS OF ASSEMBLING SAME

### CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 63/556,311, filed Feb. 21, 2024, the disclosure of which is hereby incorporated by reference in its entirety.

### FIELD OF THE INVENTION

[0002] This invention relates generally to personal protective vests including body armor panels.

### BACKGROUND OF THE INVENTION

[0003] At least some known personal protective vests include rigid ballistic panels that are sown into the vest to provide the wearer protection from small arms fire. These rigid ballistic panels do not allow for a freedom of movement that is desired by security personal to provide additional comfort and flexibility, while providing a high level of safety protection.

[0004] The present invention addresses one or more of the aforementioned challenges.

### SUMMARY OF THE INVENTION

[0005] In one aspect of the present invention, a personal protective vest assembly is provided. The personal protective vest assembly includes a carrier vest including a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface, an interior facing outer surface, and an inner surface defining a front vest ballistic panel pocket therein. The forward facing outer surface includes a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis, with each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface. A flexible body armor panel is positioned within the front vest ballistic panel pocket and including a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face, each of the layered material segments including a different ballistic material.

[0006] In another aspect of the present invention, a carrier vest is provided. The carrier vest includes a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel

body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface and an interior facing outer surface. The forward facing outer surface includes a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis, with each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0008] FIG. 1 is a perspective view of a personal protective vest assembly including a carrier vest and body armor panels, according to an embodiment of the present invention;

[0009] FIG. 2 is a front view of the carrier vest shown in FIG. 1;

[0010] FIG. 3 is a rear view of the carrier vest shown in FIG. 1;

[0011] FIG. 4 is a left side view of the carrier vest shown in FIG. 1;

[0012] FIG. 5 is a right side view of the carrier vest shown in FIG. 1;

[0013] FIG. 6 is a top view of the carrier vest shown in FIG. 1;

[0014] FIG. 7 is a bottom view of the carrier vest shown in FIG. 1;

[0015] FIG. 8 is a front view of a portion of the carrier vest shown in FIG. 1;

[0016] FIG. 9 is a rear view of a portion of the carrier vest shown in FIG. 1;

[0017] FIG. 10 is a schematic view of attachment straps that may be used with the carrier vest shown in FIG. 1;

[0018] FIGS. 11-18 are perspective views of the personal protective vest assembly shown in FIG. 1;

[0019] FIGS. 19-22 are schematic views of a body armor panel that may be used with the personal protective vest assembly shown in FIG. 1;

[0020] FIGS. 23 and 24 are schematic cross-sectional views of the body armor panel shown in FIGS. 19-22;

[0021] FIG. 25 is a cross-sectional view of the body armor panel shown in FIG. 23;

[0022] FIG. 26 is a partial view of a strike face of the body armor panel shown in FIG. 23;

[0023] FIG. 27 is a partial view of a wear face of the body armor panel shown in FIG. 23;

[0024] FIGS. 28 and 29 are flowcharts illustrating a method of manufacturing the body armor panel;

[0025] FIG. 30 is a schematic view of a system used to manufacture the body armor panel; and

[0026] FIGS. 31-34 are schematic views of a brass mold and ballistic material panel assembly used to form the body armor panel.

[0027] Corresponding reference characters indicate corresponding parts throughout the drawings.

#### DETAILED DESCRIPTION OF THE INVENTION

[0028] In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of various embodiments of the present invention. Also, common but well-understood elements that are useful or necessary in a commercially feasible embodiment are often not depicted in order to facilitate a less obstructed view of these various embodiments of the present invention. It will be apparent, however, to one having ordinary skill in the art that the specific detail need not be employed to practice the present invention. In other instances, well-known materials or methods have not been described in detail in order to avoid obscuring the present invention.

[0029] In general, the present invention describes a personal protective vest system that includes a soft-flexible armor panel that is inserted into a personal protective vest. In some embodiments, the personal protective vest system includes the Hyperline™ soft-flexible armor panel provided by Safe Life Defense™.

[0030] Referring to FIGS. 1-27, in the illustrated embodiment, the present invention includes a personal protective vest assembly 10 that includes a wearable personal protective carrier vest 12 and one or more body armor panels 14 inserted into the carrier vest 12. In some embodiments, the carrier vest 12 is configured to be worn by a person covering a portion of the person's torso. In other embodiments, the personal protective vest assembly 10 may include other wearable protective articles that cover other areas of a person's body such as, for example, wearable protective articles covering the lower body, arms, legs, and head.

[0031] In some embodiments, the carrier vest 12 includes the Hyper Concealable™ Carrier™ provided by Safe Life Defense™ (shown in FIGS. 1-18). The carrier vest 12 is composed of: a main body fabric weighing less than: 0.39 lbs per square foot; a lightweight Velcro; the main garment (not including straps) contains materials that are overlapped and stitched or welded onto one another; and stitching composed of flatlock seams without overlapping materials. This carrier vest 12 uses materials and assembly methods to be as low profile as possible at only 0.03" thick. The carrier vest 12 includes the following features: Engineered specifically for Hyperline™ Soft Armor Panels; Incredibly thin: Only 0.03" thick; 12 point adjustable with Low Profile Ultrasonic Comfort Straps; Capable of being worn comfortably directly on the skin; DTF Ultra low profile non-itch tags; Water Resistant brushed polyester fabric; Flat Stitching.

[0032] In the illustrated embodiment, the carrier vest 12 includes a front vest panel assembly 16 and a rear vest panel assembly 18. In some embodiments, the front vest panel assembly 16 may be removable coupled to the rear vest panel assembly 18 with a vest fastening assembly 20. The vest fastening assembly 20 may include, for example, a Velcro™ assembly, a button assembly, and/or any suitable

fasteners that allow the front vest panel assembly 16 to removable attach to the rear vest panel assembly 18.

[0033] Each vest panel assembly 16, 18 includes an outer surface 22 and an interior facing outer surface 24 adapted to be positioned adjacent to the person's body with the carrier vest 12 worn by the person, and an inner surface 25 defining a ballistic panel pocket 26. The ballistic panel pocket 26 is defined between the outer surface 22 and the interior facing outer surface 24. The ballistic panel pocket 26 is sized and shaped to receive a body armor panel 14 therein such that the body armor panel 14 is positioned within the ballistic panel pocket 26. In some embodiments, the interior facing outer surface 24 also includes a slot 28 defined along the interior facing outer surface 24 to provide access to the ballistic panel pocket 26 to insert and/or remove body armor panel 14. A slot fastening assembly 30 may be defined along the slot 28 to allow the ballistic panel pocket 26 to be selectively sealed. The slot fastening assembly 30 may include, for example, a Velcro assembly, a button fastener assembly, and/or any suitable fasteners that allow the slot 28 and ballistic panel pocket 26 to be sealed.

[0034] In the illustrated embodiment, the front vest panel assembly 16 is adapted to overlay a chest of the wearer and the rear vest panel assembly 18 adapted to overlay a back of the wearer. The front vest panel assembly 16 includes a front vest panel body 400 extending between a front vest upper portion 402 and a front vest lower portion 404 along a vertical axis 406, and between opposing front vest side edges 408 along a horizontal axis 410. The front vest panel body 400 includes a forward facing outer surface 412, an interior facing outer surface 414, and an inner surface 25 defining a front vest ballistic panel pocket 26 therein. The front vest upper portion 402 defines a front vest upper width 416 of the front vest panel assembly 16 along the horizontal axis 410 and the front vest lower portion 404 defines a front vest lower width 418 of the front vest panel assembly 16 along the horizontal axis 410 that is larger than the front vest upper width 416.

[0035] The forward facing outer surface 412 includes a pair of lower front vest fastening sections 420 defined along the front vest lower portion 404 and orientated in a mirrored relationship along the vertical axis 406. Each lower front vest fastening section 420 includes hook & loop fabric material 422 (e.g., Velcro™) extending from a corresponding front vest side edge 408 towards a center of the front vest lower portion 404. Each lower front vest fastening section 420 includes an interior edge 424 that is spaced a distance from the corresponding front vest side edge 408 and has a concave arcuate shape extending from an upper end 426 of the front vest lower portion 404 to a bottom edge 428 of the forward facing outer surface 412 such that a lower end 430 of the interior edge 424 adjacent the bottom edge 428 of the forward facing outer surface 412 is closer to the center of the front vest lower portion 404 than a top end 432 of the interior edge 424. The pair of lower front vest fastening sections 420 are orientated in a mirrored relationship along the vertical axis 406 such that a lower gap 434 is defined between the lower ends 430 of the opposing interior edges 424, and an upper gap 436 is defined between the top ends 432 of the opposing interior edges 424 that is larger than the lower gap 434.

[0036] The front vest upper portion 402 also includes opposing shoulder portions 438 defining an arcuate concave neckline 440. The forward facing outer surface 412 includes

a pair of opposing upper front vest fastening sections **442** defined along the front vest upper portion **402** and orientated in a mirrored relationship along the vertical axis **406**. Each upper front vest fastening section **442** includes hook & loop fabric material **422** extending across a corresponding shoulder portion **438** and including a bottom edge **444** extending from the neckline **440** to a corresponding front vest side edge **408** at a downward oblique angle such that an upper gap **446** is defined between the top ends of the opposing bottom edges **444** and a lower gap **448** is defined between the lower ends of the opposing bottom edges **444** that is larger than the upper gap **446**.

[0037] The front vest panel assembly **16** also includes a front vest central portion **450** having a smooth surface extending between each lower front vest fastening section **420** and each upper front vest fastening section **442**. In some embodiments, the front vest central portion **450** is coupled to the lower front vest fastening sections **420** and to the upper front vest fastening sections **442** via flat stitching formed along the interior edges **424** of the lower front vest fastening sections **420** and the bottom edges **444** of the upper front vest fastening sections **442**.

[0038] A first flexible body armor panel **14** is positioned within the front vest ballistic panel pocket **26** and includes a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face with each of the layered material segments including a different ballistic material. In some embodiments, the first flexible body armor panel **14** defines a perimeter shape that is substantially the same as a perimeter shape of the front vest panel body **400**.

[0039] In the illustrated embodiment, the rear vest panel assembly **18** includes a rear vest panel body **452** extending between a rear vest upper portion **454** and a rear vest lower portion **456** along the vertical axis **406**, and between a first rear vest side edge **458** and an opposing second rear vest side edge **460** along the horizontal axis **410**. The rear vest upper portion **454** defines a rear vest upper width **462** of the rear vest panel assembly **18** along the horizontal axis **410** and the rear vest lower portion **456** defines a rear vest lower width **464** of the rear vest panel assembly **18** along the horizontal axis **410** that is larger than the rear vest upper width **462**. In some embodiments, the rear vest upper width **462** is larger than the front vest upper width **416** of the front vest panel assembly **16**, and the rear vest lower width **464** is substantially equal in length to the front vest lower width **418**.

[0040] In the illustrated embodiment, the rear vest panel body **452** includes a rear vest forward facing outer surface **466** and a rear vest interior facing outer surface **468**. The rear vest panel body **452** also includes a rear vest inner surface **25** defining a rear vest ballistic panel pocket **26** therein. A second flexible body armor panel **14** is positioned within the rear vest ballistic panel pocket **26** and may include a ballistic material panel that is similar to the ballistic material panel of the first flexible body armor panel **14**. In some embodiments, the second flexible body armor panel **14** defines a perimeter shape that is substantially the same as a perimeter shape of the rear vest panel body **452**.

[0041] The rear vest forward facing outer surface **466** includes a lower rear vest fastening section **470** that is defined along the rear vest lower portion **456** and includes hook & loop fabric material **422** extending from a top end **472** of the rear vest lower portion **456** to a bottom edge **474**

of the rear vest forward facing outer surface **466**, and from the first rear vest side edge **458** to the opposing second rear vest side edge **460**.

[0042] The rear vest upper portion **454** also includes opposing rear vest shoulder portions **476** defining an arcuate concave rear vest neckline **478** therebetween. The rear vest forward facing outer surface **466** includes a pair of opposing upper rear vest fastening sections **480** defined along the rear vest upper portion **454** and orientated in a mirrored relationship along the vertical axis **406**. Each upper rear vest fastening section **480** includes hook & loop fabric material **422** extending across a corresponding rear vest shoulder portion **476** and including a bottom edge **482** extending from the rear vest neckline **478** to a corresponding rear vest side edge **458, 460** at a downward oblique angle such that a rear vest upper gap **484** is defined between the top ends of the opposing bottom edges **482** and a rear vest lower gap **486** is defined between the lower ends of the opposing bottom edges **482** that is larger than the rear vest upper gap **484**.

[0043] The rear vest panel assembly **18** includes a rear vest central portion **488** having a smooth surface extending between the lower rear vest fastening section **470** and each of the upper rear vest fastening sections **480**. The rear vest central portion **488** is coupled to the lower rear vest fastening section **470** and to the upper rear vest fastening sections **480** via flat stitching formed along a top edge **490** of the lower rear vest fastening section **470** and the bottom edges **482** of the upper rear vest fastening sections **480**.

[0044] The vest fastening assembly **20** includes a plurality of attachment straps **492** that are removably coupled to the front vest panel assembly **16** and the rear vest panel assembly **18**. Each attachment strap **492** includes a pair of opposing fastening tabs **494** that each including hook & loop fabric material **422** defined along an outer surface to facilitate removable coupling the attachment strap **492** to the corresponding hook & loop fabric material **422** defined along the front vest forward facing outer surface **412** and the rear vest forward facing outer surface **466**. Each attachment strap **492** also includes a flexible section **496** including an elastic material extending between the opposing fastening tabs **494** to enable the wearer to adjust a width and overall fit of the carrier vest **12** around the wearer's body.

[0045] In the illustrated embodiment, the vest fastening assembly **20** includes a pair of upper attachment straps **498** that are removably coupled to a corresponding upper front vest fastening section **442** and a corresponding upper rear vest fastening section **480**. The vest fastening assembly **20** also includes two pairs of side attachment straps **500** with each pair of side attachment straps **500** removably coupled to the lower rear vest fastening section **470** and a corresponding lower front vest fastening section **420**. Each pair of side attachment straps **500** includes an upper side attachment strap **502** and a lower side attachment strap **504**. The lower side attachment strap **504** is positioned closer to a bottom of the carrier vest **12** than the upper side attachment strap **502**, and includes a length **506** defined between corresponding opposing fastening tabs **494** that is longer than a length **508** of the upper side attachment strap **502**.

[0046] By providing the forward facing outer surface **412** having opposing lower front vest fastening sections **420** with concave arcuate shape interior edges **424** and corresponding side attachment straps **500** including upper and lower side attachment straps **502, 504**, the ability of the wearer to adjust the width and overall fit of the carrier vest **12** is improved.

[0047] In the illustrated embodiment, the body armor panel 14 includes an outer cover 32 that defines a panel assembly cavity 34 and a ballistic material panel assembly 36 that is positioned within the panel assembly cavity 34. The outer cover 32 may include a 30 denier thermoplastic polyurethane laminated nylon fabric. In some embodiments, the body armor panel 14 includes a cross-sectional shape substantially similar to the cross-sectional shape of the corresponding vest panels 16, 18. In other embodiments, the body armor panel 14 may include any suitable cross-sectional shape to facilitate covering any portion of a person's body.

[0048] The ballistic material panel assembly 36 includes a plurality of layered material segments 38, 40, 42, 44 defined between a strike face 46 and a wear face 48, with each of the layered material segments 38, 40, 42, 44 including a different ballistic material. When positioned within the ballistic panel pocket 26 the strike face 46 is orientated near the outer surface 22 of the corresponding vest panel 16, 18 and the wear face 48 is orientated near the interior facing outer surface 24 of the corresponding vest panel 16, 18 such that the wear face 48 is closer to a person's body than the strike face 46 with the carrier vest 12 worn by the person.

[0049] In the illustrated embodiment, the plurality of layered material segments includes a first layered material segment 38 that includes a layer of a first ballistic material 50, a second layered material segment 40 that is adjacent the first layered material segment 38 and includes a plurality of layers of a second ballistic material 52, a third layered material segment 42 that is adjacent the second layered material segment 40 and includes a plurality of layers of a third ballistic material 54, and a fourth layered material segment 44 that is adjacent the third layered material segment 42 and includes a plurality of layers of a fourth ballistic material 56. The first layered material segment 38 defines the strike face 46 and the fourth layered material segment 44 defines the wear face 48. A number of layers of the third ballistic material 54 is greater than a number of layers of the second ballistic material 52, and a number of layers of the fourth ballistic material 56 is less than the number of layers of the third ballistic material 54.

[0050] In some embodiments, as shown in FIG. 23, the first layered material segment 38 includes a single layer of the first ballistic material 50, the second layered material segment 40 includes four layers of the second ballistic material 52, the third layered material segment 42 includes eight layers of the third ballistic material 54, and the fourth layered material segment 44 includes four layers of the fourth ballistic material 56. In other embodiments, each segment 38, 40, 42, 44 may include any suitable number of layers of corresponding ballistic material.

[0051] The first ballistic material 50 includes an ultra-high molecular weight polyethylene fiber based composite laminate having an Areal density of about between 226 g/m<sup>2</sup> and 240 g/m<sup>2</sup> including four single layers of unidirectional sheet cross plied at 90 degrees to each other and consolidated with a rubber based matrix. In some embodiments, the first ballistic material may include DSM Dyneema® HB50 with the first layered material segment 38 includes a single layer of DSM Dyneema® HB50.

[0052] The second ballistic material 52 includes an ultra-high molecular weight polyethylene fiber based composite laminate having an Areal density of about between 208 g/m<sup>2</sup> and 224 g/m<sup>2</sup> including six single layers of unidirectional

sheet cross plied at 90 degrees to each other and consolidated with a rubber based matrix. In some embodiments, the second ballistic material may include DSM Dyneema® SB117 with the second layered material segment 40 including four layers of DSM Dyneema® SB117.

[0053] The third ballistic material 54 includes para-aramid unidirectional material including four plies of para-aramid unidirectional material cross-plied in 0°/90°/0°/90° configuration. In some embodiments, the third ballistic material 54 may include Barrday Advanced Material Solutions™ U611 with the third layered material segment 42 including eight layers of Barrday Advanced Material Solutions™ U611.

[0054] The fourth ballistic material 56 includes a woven and laminated material having an Areal density of about 516 g/m<sup>2</sup>. In some embodiments, the fourth ballistic material 56 may include Barrday Advanced Material Solutions™ FCKER1017160-01129 with the fourth layered material segment 44 including four layers of Barrday Advanced Material Solutions™ FCKER1017160-01129.

[0055] As shown in FIG. 24, in some embodiments, the plurality of layered material segments includes the first layered material segment 38 including a single layer of the first ballistic material 50, the second layered material segment 40 including six layers of the second ballistic material 52, the third layered material segment 42 including six layers of the third ballistic material 54, and the fourth layered material segment 44 including a plurality of layers of the third ballistic material 54 and a plurality of layers of the fourth ballistic material 56 positioned in an alternating layered arrangement such that each layer of the third ballistic material 54 is positioned between corresponding layers of the fourth ballistic material 56. For example, the fourth layered material segment 44 may include four layers of the fourth ballistic material 56 interlaced with three layers of the third ballistic material 54 such that a top layer of fourth ballistic material 56 is adjacent a bottom layer of third ballistic material 54 of the third layered material segment 42, and a bottom layer of fourth ballistic material 56 defines the wear face 48.

[0056] In some embodiments, as shown in FIGS. 19-21, the body armor panel 14 includes a cross-sectional shape defining a lower portion 70 and an upper portion 72 extending from the lower portion 70. The upper portion 72 has a first width 74, and the lower portion 70 has a second width 76 that is larger than the first width 74 of the upper portion 72. The body armor panel 14 also has a pair of opposing side walls 78, 80 that extend from the lower portion 70 to the upper portion 72 at opposing oblique angles. The upper portion 72 also includes an arcuate surface 82 defined along a top edge 84 of the upper portion 72. In other embodiments, as shown in FIG. 22, the body armor panel 14 may include a substantially rectangular cross-sectional shape.

[0057] FIG. 28 is a flowchart illustrating a method 200 of manufacturing the body armor panel 14. The method includes a plurality of steps. Each method step may be performed independently of, or in combination with, other method steps. In the illustrated embodiment, the method 200 includes positioning the ballistic material panel assembly 36 within a dual platen heated press including placing the layered material segments 38, 40, 42, 44 within the dual platen heated press such that the first layered material segment 38 defines the strike face 46, the second layered material segment 40 is between the first layered material segment 38 and the third layered material segment 42, and

the fourth layered material segment 44 is adjacent the third layered material segment 42 and defines the wear face 48.

[0058] The dual platen heated press is then operated to apply a heat process to the ballistic material panel assembly 36 including applying heat at a first temperature from the strike face 46, applying heat at a different second temperature from the wear face 48, and applying pressure to the ballistic material panel assembly 36 during the heat process. In some embodiments, the first temperature is between about 250 and 300° Fahrenheit and the second temperature is between about 150 and 225° Fahrenheit, with the applied pressure at about 80 psi.

[0059] The ballistic material panel assembly 36 is then removed from the dual platen heated press after a first predefined elapsed period of time. For example, in some embodiments, the first predefined elapsed period of time is about 1.5 minutes. The ballistic material panel assembly 36 is allowed to cool for a second elapsed period of time and then cut to a desired shaped. In some embodiments, the second predefined elapsed period of time is about 30 seconds.

[0060] In some embodiments, the Hyperline™ soft armor panel is constructed by layering ballistic material in a 0°/0° orientation in a layered material configuration from strike face to wear face including: 1 Layer—DSM Dyneema® HB50; 4 Layers—DSM Dyneema® SB117; 8 Layers—Barday Advanced Material Solutions™ U611; and 4 Layers—Barday Advanced Material Solutions™ FCKER1017160-01129. The layered materials are feed into a dual platen heated press that is used to apply heat at a temperature of 250-300 degrees Fahrenheit from the strike face layer. A temperature of 150-225 degrees Fahrenheit is applied from the opposite platen to the wear face layer. Pressure is applied during the heat process at no less than 80 psi. After a minimum of 1.5 minutes the press is released and the materials is removed from the machinery and is allowed to cure for a period of no less than 30 seconds. The armor packet may be consolidated in a full sheet from which shapes may be cut by using a multi ply cutter, precision rotary blade or die cutter, or, layers may be pre-cut into uniform shapes that are layered and consolidated using the above process.

[0061] The ballistic material panel assembly 36 is sealed inside an outer cover 32 including water resistant TPU material such as, for example, Brookwood™ Cover HST 30d. The TPU is sealed using a High Frequency Ultrasonic Welding Machine. In some embodiments, the body armor panel 14 includes a High Frequency Weld (HFW) seal 58 about the perimeter of the ballistic material panel assembly 36 having a width of about 0.25 inches+/-0.25 inches, with a maximum gap 60 between the ballistic panel 36 and the HFW seal 58 of about 0.25 inches+/-0.2 inches, with an overcut 62 having a maximum allowable width equal to 0.5 inches. A thermal label with an adhesive backing is then applied to the wear face of the sealed ballistic panel.

[0062] FIG. 29 is a flowchart illustrating another method 300 of manufacturing the body armor panel 14. FIG. 30 is a schematic view of a system 100 used to manufacture the body armor panel 14. In the illustrated embodiment, the system 100 includes a fabric spreading and cutting machine 102, a first industrial conveyor oven machine 104, a hydraulic press machine 106, a high frequency ultrasonic welding machine 108, a second industrial conveyor oven machine 110, and a belt press machine 112. In method step 302, the

plurality of layered material segments are fed through the fabric spreading and cutting machine 102 and cut to pre-defined cross-sectional shapes to form a pre-cut, layered ballistic material panel assemblies 36.

[0063] In method step 304, a first heat treatment is applied to a pre-cut, layered ballistic material panel assembly 36 to increase a temperature of the ballistic material panel assembly to a predefined temperature. The first heat treatment may be applied to increase the temperature of the ballistic material panel assembly to the predefined temperature between about 150° and 190° Fahrenheit. For example, the pre-cut, layered ballistic material panel assembly 36 may be positioned within an industrial heat tunnel, i.e., the first industrial conveyor oven machine 104, for a predefined period of time to increase the temperature of the ballistic material panel assembly to the predefined temperature between about 150° and 190° Fahrenheit. In some embodiments, applying the first heat treatment includes operating the industrial heat tunnel at an internal temperature between about 300° and 350° Fahrenheit, and positioning the ballistic material panel assembly within the heat tunnel for an elapsed heating time between about 1 minute and 2 minutes. For example, the first heat treatment may include feeding the pre-cut, layered ballistic material panel assembly 36 through the first industrial conveyor oven machine 104 operated with a heated environment of about 335° F. for 1 minute and 50 seconds. In some embodiments, a reflective adhesive vinyl sticker 86 is applied onto a top layer (i.e., the strike face 46) of the ballistic material panel assembly 36 prior to the first heat treatment.

[0064] In method step 306, a compression treatment is applied to the heated ballistic material panel assembly at a predefined pressure and a predefined period of time to form a hardened ballistic material panel assembly. For example, upon completion of the first heat treatment, the heated ballistic material panel assembly is removed from the first industrial conveyor oven machine 104 and positioned onto the hydraulic press machine 106. The hydraulic press machine 106 is then operated to apply the compression treatment including applying a pressure between about 100 to 500 tons to the heated ballistic material panel assembly. The compression treatment may include, for example, applying a pressure between about 100 to 500 tons to the heated ballistic material panel assembly for a period of 30 seconds. In some embodiments, the compression treatment may include applying 200 tons of pressure to the heated ballistic material panel assembly for a period of 30 seconds to form a hardened ballistic material panel assembly.

[0065] In embodiments in which the reflective adhesive vinyl sticker 86 has been applied onto the strike face 46 of the ballistic material panel assembly 36 prior to the first heat treatment, the compression treatment embeds the reflective adhesive vinyl sticker 86 into the strike face 46 such that surface of reflective adhesive vinyl sticker 86 is substantially flush with the strike face 46 of the hardened ballistic material panel assembly.

[0066] In method step 308, the hardened ballistic material panel assembly 36 is positioned within the outer cover 32 and the outer cover 32 is welded to form a perimeter seam about a perimeter of the hardened ballistic material panel assembly to seal the hardened ballistic material panel assembly within the outer cover to form a body armor panel 14. For example, as shown in FIGS. 29-34, the upon completing the compression treatment, the hardened ballistic material

panel assembly **36** may be positioned between two layers of pre-cut outer cover material (e.g., Brookwood™ Cover HST 30d) having a cross-sectional shape substantially similar to the hardened ballistic material panel assembly **36**, and placed on a bottom plate **114** of the high frequency ultrasonic welding machine **108**. A brass mold assembly **116** having cross-sectional shape substantially similar to the hardened ballistic material panel assembly **36** is positioned over a top layer of the pre-cut outer cover material such that the hardened ballistic material panel assembly **36** is positioned within a cavity **118** defined through the brass mold assembly **116**. A compressible insert **120** is then placed within the cavity **118** on top of the hardened ballistic material panel assembly **36** and outer cover **32**. The compressible insert **120** includes a thickness **122** such that a top surface **124** of the compressible insert **120** is spaced a vertical distance **126** above an upper surface **128** of the brass mold assembly **116** with the compressible insert **120** contacting the outer cover **32**. As shown in FIG. 34, as a top plate **130** of the high frequency ultrasonic welding machine **108** is moved to contact the brass mold assembly **116**, the top plate **130** contacts the compressible insert **120** to cause the compressible insert **120** to compress and apply pressure onto the hardened ballistic material panel assembly **36** and outer cover **32** to force air trapped between the hardened ballistic material panel assembly **36** and outer cover **32** towards the perimeter of the outer cover **32** before the top plate **130** contacts the brass mold assembly **116**. Once the top plate **130** is in contact with the brass mold assembly **116**, the high frequency ultrasonic welding machine **108** is operated to weld a perimeter seam along the outer cover **32** via the brass mold assembly **116** to form a vacuum seal between the hardened ballistic material panel assembly **36** and the outer cover **32**.

[0067] In some embodiments, the high frequency ultrasonic welding machine **108** is operated to seal the hardened ballistic material panel assembly **36** within a water resistance thermo-plastic packaging. The water resistance thermo-plastic packaging may include a semi-transparent thermo-plastic material such that the reflective adhesive vinyl sticker **86** is visible through the water resistance thermo-plastic outer cover. In some embodiments, the compressible insert **120** includes a Nomex® material positioned within the brass mold assembly **116**. As the high frequency ultrasonic welding machine **108** operates the top plate **130** to lower and contact the brass mold assembly **116**, the top plate **130** contacts the Nomex insert to apply pressure to the top layer of water-resistance material to remove air between top/bottom layers of material and the hardened ballistic material panel assembly **36** to facilitate eliminating air from the body armor panel **14**. The high frequency ultrasonic welding machine **108** then applies high frequency radio waves to water resistance material layers through brass mold assembly to form the perimeter weld to seal the hardened ballistic material panel assembly **36** within the water resistant outer cover packaging and form an air-tight seal. The air-tight seal facilitates maintaining the shape of the assembled panel.

[0068] In another embodiment, the first heat treatment and the compression treatment are applied to only a portion of the plurality of the plurality of layered material segments **38**, **40**, **42**, **44**. For example, in some embodiments, the first heat treatment and the compression treatment are applied only to the first and second layered material segments **38**, **40** to form

a partially hardened ballistic material panel assembly. The partially hardened ballistic material panel assembly is then layered onto the third layered material segment **42** and/or the fourth layered material segment **44** to form the completed ballistic material panel assembly, which is then placed within the outer cover **32** and into the high frequency ultrasonic welding machine **108** to weld the perimeter seam about the completed ballistic material panel assembly.

[0069] In other embodiments, the first heat treatment and the compression treatment are applied only to the third layered material segment **42** and/or the fourth layered material segment **44** to form the partially hardened ballistic material panel assembly. The first and second layered material segments **38**, **40** are then layered on top of the partially hardened ballistic material panel assembly to form the completed ballistic material panel assembly prior to welding the outer cover **32** onto the completed ballistic material panel assembly.

[0070] In method step **310**, a second heat treatment is applied to the body armor panel **14** to increase a temperature of the body armor panel **14** to a second predefined temperature. For example, after the hardened ballistic material panel assembly **36** has been welded within the outer cover **32** to form the sealed body armor panel **14**, the sealed body armor panel **14** is then placed into the second industrial conveyor oven machine **110** for a predefined period of time to increase the temperature of the sealed body armor panel **14** to facilitate increasing a flexibility of the sealed body armor panel **14**. The second industrial conveyor oven machine **110** is operated at a lower internal temperature than the first industrial conveyor oven machine **104**.

[0071] In method step **312**, a conditioning treatment is then applied to the heated body armor panel **14** to increase a flexibility of a conditioned body armor panel **14**. For example, after the second heat treatment is completed, the heated body armor panel **14** is fed through a belt press machine **112** that includes a pair of opposing conveyor belt systems that form roller pairs of varying heights. As the heated body armor panel **14** is moved through the roller pairs the heated body armor panel **14** is moved through various vertical positions, thereby breaking-in the heated body armor panel **14** to increase the flexibility of the finished, conditioned body armor panel **14**.

[0072] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

[0073] Although specific features of various embodiments of the disclosure may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the disclosure, any feature of a drawing or other embodiment may be referenced and/or claimed in combination with any feature of any other drawing or embodiment.

[0074] This written description uses examples to describe embodiments of the disclosure and also to enable any person skilled in the art to practice the embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent

structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A personal protective vest assembly comprising:  
a carrier vest including:  
a front vest panel assembly adapted to overlay a chest of the wearer;  
a rear vest panel assembly adapted to overlay a back of the wearer; and  
a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly;  
the front vest panel assembly including a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis;  
the front vest panel body including a forward facing outer surface, an interior facing outer surface, and an inner surface defining a front vest ballistic panel pocket therein;  
the forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis;  
each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface; and  
a first flexible body armor panel positioned within the front vest ballistic panel pocket and including a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face, each of the layered material segments including a different ballistic material.

2. The personal protective vest assembly of claim 1, wherein the front vest upper portion includes opposing shoulder portions defining an arcuate concave neckline, the forward facing outer surface includes a pair of opposing upper front vest fastening sections defined along the front vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper front vest fastening section including hook & loop fabric material extending across a corresponding shoulder portion and including a bottom edge extending from the neckline to a corresponding front vest side edge at a downward oblique angle.

3. The personal protective vest assembly of claim 2, wherein the front vest panel assembly includes a front vest central portion having a smooth surface extending between each lower front vest fastening section and each upper front vest fastening section.

4. The personal protective vest assembly of claim 2, wherein the rear vest panel assembly includes:

- a rear vest panel body extending between a rear vest upper portion and a rear vest lower portion along the vertical axis and between a first rear vest side edge and an opposing second rear vest side edge along the horizontal axis;

the rear vest panel body including a rear vest forward facing outer surface and a rear vest interior facing outer surface; and

the rear vest forward facing outer surface including a lower rear vest fastening section defined along the rear vest lower portion including hook & loop fabric material extending from a top end of the rear vest lower portion to a bottom edge of the rear vest forward facing outer surface and from the first rear vest side edge to the opposing second rear vest side edge.

5. The personal protective vest assembly of claim 4, wherein the rear vest panel body includes a rear vest inner surface defining a rear vest ballistic panel pocket therein, the carrier vest includes a second flexible body armor panel positioned within the rear vest ballistic panel pocket.

6. The personal protective vest assembly of claim 4, wherein the rear vest upper portion includes opposing rear vest shoulder portions defining an arcuate concave rear vest neckline, the rear vest forward facing outer surface includes a pair of opposing upper rear vest fastening sections defined along the rear vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper rear vest fastening section including hook & loop fabric material extending across a corresponding rear vest shoulder portion and including a bottom edge extending from the rear vest neckline to a corresponding rear vest side edge at a downward oblique angle.

7. The personal protective vest assembly of claim 6, wherein the rear vest panel assembly includes a rear vest central portion having a smooth surface extending between the lower rear vest fastening section and each of the upper rear vest fastening sections.

8. The personal protective vest assembly of claim 6, wherein the plurality of attachment straps includes a pair of upper attachment straps removably coupled to a corresponding upper front vest fastening section and a corresponding upper rear vest fastening section.

9. The personal protective vest assembly of claim 8, wherein the plurality of attachment straps includes two pairs of side attachment straps, each pair of side attachment straps removably coupled to the lower rear vest fastening section and a corresponding lower front vest fastening section.

10. The personal protective vest assembly of claim 9, wherein each pair of side attachment straps includes an upper side attachment strap and a lower side attachment strap, the lower side attachment strap positioned closer to a bottom of the carrier vest than the upper side attachment strap and including a length that is longer than a length of the upper side attachment strap.

11. The personal protective vest assembly of claim 1, wherein each attachment strap includes a pair of opposing fastening tabs each including hook & loop fabric material defined along an outer surface and a flexible section including an elastic material extending between the opposing fastening tabs.

12. A carrier vest comprising:  
a front vest panel assembly adapted to overlay a chest of the wearer;  
a rear vest panel assembly adapted to overlay a back of the wearer; and  
a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly;

the front vest panel assembly including a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis;

the front vest panel body including a forward facing outer surface and an interior facing outer surface;

the forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis;

each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface.

**13.** The carrier vest of claim **12**, wherein the front vest upper portion includes opposing shoulder portions defining an arcuate concave neckline, the forward facing outer surface includes a pair of opposing upper front vest fastening sections defined along the front vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper front vest fastening section including hook & loop fabric material extending across a corresponding shoulder portion and including a bottom edge extending from the neckline to a corresponding front vest side edge at a downward oblique angle.

**14.** The carrier vest of claim **13**, wherein the front vest panel assembly includes a front vest central portion having a smooth surface extending between each lower front vest fastening section and each upper front vest fastening section.

**15.** The carrier vest of claim **13**, wherein the rear vest panel assembly includes:

a rear vest panel body extending between a rear vest upper portion and a rear vest lower portion along the vertical axis and between a first rear vest side edge and an opposing second rear vest side edge along the horizontal axis;

the rear vest panel body including a rear vest forward facing outer surface and a rear vest interior facing outer surface; and

the rear vest forward facing outer surface including a lower rear vest fastening section defined along the rear vest lower portion including hook & loop fabric material extending from a top end of the rear vest lower portion to a bottom edge of the rear vest forward facing outer surface and from the first rear vest side edge to the opposing second rear vest side edge.

**16.** The carrier vest of claim **15**, wherein the rear vest upper portion includes opposing rear vest shoulder portions defining an arcuate concave rear vest neckline, the rear vest forward facing outer surface includes a pair of opposing upper rear vest fastening sections defined along the rear vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper rear vest fastening section including hook & loop fabric material extending across a corresponding rear vest shoulder portion and including a bottom edge extending from the rear vest neckline to a corresponding rear vest side edge at a downward oblique angle.

**17.** The carrier vest of claim **16**, wherein the rear vest panel assembly includes a rear vest central portion having a smooth surface extending between the lower rear vest fastening section and each of the upper rear vest fastening sections.

**18.** The carrier vest of claim **16**, wherein the plurality of attachment straps includes a pair of upper attachment straps removably coupled to a corresponding upper front vest fastening section and a corresponding upper rear vest fastening section.

**19.** The carrier vest of claim **18**, wherein the plurality of attachment straps includes two pairs of side attachment straps, each pair of side attachment straps removably coupled to the lower rear vest fastening section and a corresponding lower front vest fastening section.

**20.** The carrier vest of claim **19**, wherein each pair of side attachment straps includes an upper side attachment strap and a lower side attachment strap, the lower side attachment strap positioned closer to a bottom of the carrier vest than the upper side attachment strap and including a length that is longer than a length of the upper side attachment strap.

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