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- (71) **Applicant:** **HILL-ROM SERVICES, INC.** [US/US];  
1069 State Route 46 East, Batesville, Indiana 47006 (US).
- (72) **Inventors:** **RIBBLE, David Lance**; 525 East New York  
Street, Indianapolis, Indiana 46202 (US). **AGDEPPA,**  
**Eric D.**; 24 Winding Way, Apt. 101, Batesville, Indiana  
47006 (US). **WIGGERMANN, Neal**; 1161 Tekulve Road,  
Apt. 401-20, Batesville, Indiana 47006 (US). **HOOD, Mi-**  
**chael S.**; 51 Pine Grove Drive, Batesville, Indiana 47006  
(US). **HOWELL, Charles A.**; 106 White Oak Drive,  
Batesville, Indiana 47006 (US). **PENNINGER, Jason A.**;  
5846 Forest Lane, Indianapolis, Indiana 46220 (US).

**SRIVASTAVA, Varad**; 129 Fitch Avenue, Apt. 4, Batesville, Indiana 47006 (US). **WILLIAMS, Joshua A.**; 603 Laura Court, Harrison, Ohio 45030 (US). **BRANSON, Gregory W.**; 323 Woodfield Drive, Batesville, Indiana 47006 (US). **SAUSER, Frank E.**; 7445 Bridge Point Pass, Cincinnati, Ohio 45248 (US). **PELO, Travis**; 14025 N. Morris Street., Apt. 9, Batesville, Indiana 47006 (US). **GAZAGNES, Laetitia**; 105 rue des Rieges, F-34080 Montpellier (FR). **DEGUIGNET, Pierre**; 7 Rue Gustave Courbet, F-34830 Clapiers (FR). **BHAI, Aziz A.**; 10404 Carlisle Way, Fishers, Indiana 46038 (US).

- (74) **Agents:** CONARD, Richard D. et al.; Barnes & Thornburg LLP, 11 South Meridian Street, Indianapolis, Indiana 46204 (US).

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- (54) Title:** ADVERSE EVENT MITIGATION SYSTEMS, METHODS AND DEVICES

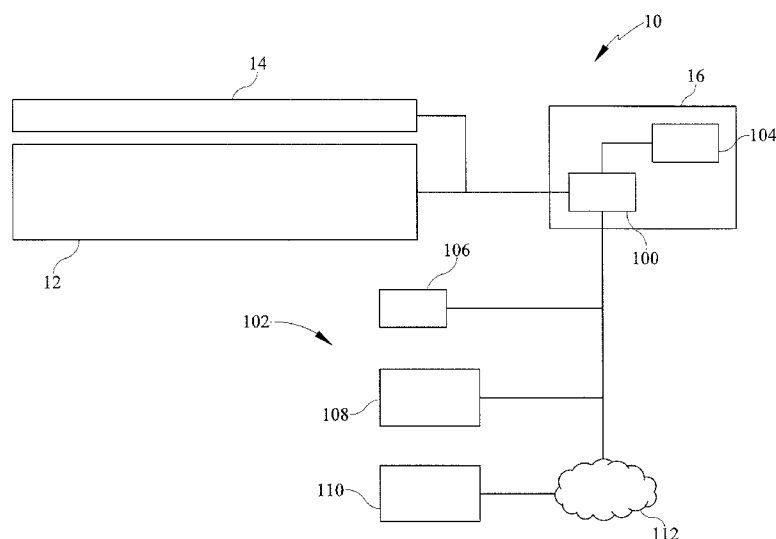


FIG. 1

- (S7) Abstract:** Methods, systems, and devices can configure a person support structure in various ways, including a configuration in which the person support structure at least temporarily assumes a progressive lateral tilt or ramp-like position.



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## ADVERSE EVENT MITIGATION SYSTEMS, METHODS AND DEVICES

## CROSS REFERENCES TO RELATED APPLICATIONS

[0001] The present application claims, under 35 U.S.C. § 119(e), the benefit of and priority to U.S. Provisional Application Nos. 61/792,911 filed March 15, 2013 and 61/896,358 filed October 28, 2013, each of which is hereby incorporated by reference herein.

## BACKGROUND OF THE DISCLOSURE

[0002] This disclosure relates generally to adverse event mitigation systems, devices and methods. More particularly, but not exclusively, one illustrative embodiment relates to a system configured to initiate an intervention to help reduce the likelihood of an adverse event occurring and/or stop an adverse event in progress. While various systems have been developed, there is still room for improvement. Thus, a need persists for further contributions in this area of technology.

## SUMMARY OF THE DISCLOSURE

[0003] A method includes determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; displaying a proposed configuration of a person support structure corresponding to the care protocol for a caregiver to approve; and upon approval by the caregiver, implementing the configuration.

[0004] A method includes receiving a signal indicative of a physiological characteristic; comparing the signal to a threshold to determine if an adverse event is in progress; and upon detecting that an adverse event is in progress, initiating an intervention to stop the adverse event.

[0005] A person support surface includes a mattress ticking and a mattress core. The mattress core is enclosed by the mattress ticking and includes at least one fluid bladder configured to selectively protrude from the person contacting surface and support a portion of at least one of the neck and the upper back of an occupant supported on the person support surface.

[0006] A method includes determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; sensing a first physiological characteristic of a person supported on a person support structure; sensing a second physiological characteristic of the person; comparing the first physiological characteristic to the second physiological characteristic; if the difference between the first

physiological characteristic and second physiological characteristic is outside a predefined range, configuring the person support structure as a function of the care protocol.

**[0007]** A method includes determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; sensing a first physiological characteristic of a person supported on a person support structure; sensing a second physiological characteristic of the person; comparing the first physiological characteristic to the second physiological characteristic; if the difference between the first physiological characteristic and second physiological characteristic is outside a predefined range, alerting a caregiver that an adverse condition is going to occur.

**[0008]** In one aspect, a support system defines a sleep surface configured to support a user thereon. The support system includes a plurality of support pieces. Each support piece defines a respective support plane having a lateral angle of rotation (or lateral rotational angle) with respect to a base surface of the support piece or an underlying surface. In a particular aspect, one or more of the respective support planes may also have a longitudinal rotational angle with respect to a base surface of the support piece or an underlying surface. A first support piece of the plurality of support pieces defines a first support plane having a lateral rotational angle different from the lateral rotational angles of the other support planes.

**[0009]** A person support apparatus to support a person in at least a horizontal position includes a number of support sections arranged along a length of the person support apparatus, where each of the support sections has a support surface to support a body portion of the person and an inflatable portion supporting the support surface, the inflatable portion of the support section is selectively inflatable and deflatable to position the support surface of the support section in a tilt position in which the support surface is angled at a maximum lateral tilt angle and position the support surface in a flat position in which the support surface is angled at a substantially flat angle, and where the support surfaces of at least two of the support sections have different maximum lateral tilt angles.

**[0010]** Additional features alone or in combination with any other feature(s), including those listed above and those listed in the claims and those described in detail below, can comprise patentable subject matter. Others will become apparent to those skilled in the art upon consideration of the following detailed description of illustrative embodiments exemplifying the best mode of carrying out the invention as presently perceived.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Referring now to the illustrative examples in the drawings, wherein like numerals represent the same or similar elements throughout:

[0012] FIG. 1 is a partial diagrammatic view of an adverse event mitigation system according to one embodiment of the current disclosure;

[0013] FIG. 2 is a side perspective view of a person support apparatus and person support surface of Fig. 1;

[0014] FIG. 3 is a cross-sectional side view of the deck of the upper frame and the person support surface of Fig. 2;

[0015] FIG. 4 is a cross-sectional view of a portion of the person support surface of Fig. 2 showing the layers of the person support surface;

[0016] FIG. 5 is a side view of the person support surface of Fig. 2 according to another embodiment showing supports configured to support the cervical vertebrae and scapula;

[0017] FIG. 6 is a block diagram of a proactive procedure according to one embodiment;

[0018] FIG. 7 is a block diagram of a reactive procedure according to one embodiment;

[0019] FIG. 8 is a block diagram of a predictive procedure according to one embodiment; and

[0020] FIG. 9 is a partial diagrammatic view of a garment configured to rotate a person.

[0021] FIGS. 10A-10C are partial diagrammatic views of a person support apparatus configured to rotate a person in accordance with one or more embodiments disclosed herein.

[0022] FIG. 11 is a perspective view of an exemplary support system supporting a user on a sleep surface defined by the support system;

[0023] FIG. 12 is a perspective side view of the support system shown in FIG. 11;

[0024] FIG. 13 is a side elevational view of the support system shown in FIG. 11;

[0025] FIG. 14 is a front elevational view of the support system shown in FIG. 11;

[0026] FIG. 15 is a schematic view of an exemplary support system;

[0027] FIG. 16 is a partial front view of the support system shown in FIG. 15 illustrating a lateral rotation of planes;

[0028] FIG. 17 is a partial side view of the support system shown in FIG. 15 illustrating a longitudinal rotation of planes;

[0029] FIG. 18 shows an exemplary control system operatively coupled to the support system shown in FIG. 15;

[0030] FIG. 19 is a side view of an exemplary support system including a plurality of independently rotatable support pieces;

[0031] FIG. 20A is a cross-sectional view of the support system shown in FIG. 19 taken along sectional line 20A in FIG. 19;

[0032] FIG. 20B is a cross-sectional view of the support system shown in FIG. 19 taken along sectional line 20A in FIG. 19 and rotated 180° about a longitudinal axis of the support system;

[0033] FIG. 21 is side view of an exemplary support system including a plurality of support pieces;

[0034] FIG. 22 is a side view of the support system shown in FIG. 21 including a spacer positioned between adjacent support pieces;

[0035] FIG. 23 is a side view of an exemplary support system including a plurality of support pieces;

[0036] FIG. 24 is a side view of the support system shown in FIG. 23 including a spacer replacing one of the support pieces;

[0037] FIG. 25 is a perspective view of an exemplary support system showing a greater number of support wedges to allow more gradual changes in edge angle along a length of a sleep surface;

[0038] FIG. 26 is a top plan view of an exemplary support system supporting a user on a sleep surface defined by the support system;

[0039] FIG. 27 is a side view of the support system shown in FIG. 26 illustrating a continuous support piece exhibiting a gradual density transition along a longitudinal length of the sleep surface;

[0040] FIG. 28 is a top plan view of an exemplary dynamic support system;

[0041] FIG. 29 is a front view of an exemplary dynamic support system;

[0042] FIG. 30 is a top view of the dynamic support system shown in FIG. 29;

[0043] FIG. 31 is a side view of the dynamic support system shown in FIG. 29 illustrating a lateral rotation of planes;

[0044] FIGS. 32-35 illustrate various configurations of fluid bladders forming at least a portion of the dynamic support system shown in FIG. 29;

[0045] FIG. 36 is a schematic view of an exemplary dynamic support system;

[0046] FIG. 37 illustrates an exemplary method for monitoring sleep activities of a user positioned on a dynamic support system, such as the support system shown in FIG. 36;

- [0047] FIGS. 38-41 illustrate an exemplary heuristic control of an apnea therapy surface function;
- [0048] FIG. 42 is a perspective view of an exemplary continuous lateral rotation therapy (CLRT) system;
- [0049] FIG. 43 is a front view of a control system configured to control the CLRT system shown in FIG. 42;
- [0050] FIG. 44 is a cross-sectional view of the support system shown in FIG. 42;
- [0051] FIG. 45 is a cross-sectional view of a portion of the support system shown in FIG. 42;
- [0052] FIG. 46 is a cross-sectional view of an exemplary support system with fixed-length bands to restrict fluid bladder inflation;
- [0053] FIG. 47 is a front perspective view of a front portion of an exemplary posture shirt;
- [0054] FIG. 48 is a rear view of a back portion of the posture shirt shown in FIG. 47;
- [0055] FIG. 49 is a top view of an exemplary chest constriction device;
- [0056] FIG. 50 is a top view of a constriction device of the chest constriction device shown in FIG. 49;
- [0057] FIG. 51 is a top view of a portion of the constriction device shown in FIG. 50 with the lever in a relaxed position;
- [0058] FIG. 52 is a top view of a portion of the constriction device shown in FIG. 50 with the lever in a constricted position;
- [0059] FIG. 53 is a simplified plan view of at least one embodiment of a person support apparatus including a number of support sections configured to position a support surface of the support section at a lateral tilt angle, shown with a top portion of the cover removed, and a simplified schematic view of an air control system in communication with the support sections of the person support apparatus;
- [0060] FIG. 54 is a simplified sectional view 54-54 of a support section of the person support apparatus of FIG. 53, where the support section is configured to position a support surface of the support section at a lateral tilt angle;
- [0061] FIG. 55 is a simplified perspective view of at least one embodiment of a support section for the person support apparatus of FIGS. 53-54;
- [0062] FIG. 56 is a simplified sectional view 56-56 of the support section of FIG. 55;

- [0063] FIG. 57 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;
- [0064] FIG. 58 is a simplified perspective view of the embodiment of FIG. 57, shown in a substantially flat position;
- [0065] FIGS. 59-60 are simplified end views of at least one embodiment of a support section for the person support apparatus of FIGS. 53-54, showing different lateral tilt angles of a support surface of the support section;
- [0066] FIG. 61 is a simplified top plan view of at least one embodiment of an arrangement of support sections and fluid communication channels for the person support apparatus of FIGS. 53-54, showing the fluid communication channels coupling the support sections to the air control system;
- [0067] FIG. 62 is a simplified top plan view of at least one embodiment of a side support member for the person support apparatus of FIGS. 53-54;
- [0068] FIG. 63 is a simplified side view of the side support member of FIG. 62, taken while the side support member is inflated;
- [0069] FIG. 64 is a simplified perspective view of at least one embodiment of a cover for the person support apparatus of FIG. 53;
- [0070] FIG. 65 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;
- [0071] FIG. 66 is a simplified perspective view of the embodiment of FIG. 65, shown in a substantially flat position;
- [0072] FIG. 67 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;
- [0073] FIG. 68 is a simplified perspective view of the embodiment of FIG. 67, shown in a flat position;
- [0074] FIG. 69 is a simplified perspective view of at least one embodiment of a support section for the person support apparatus of FIG. 53;
- [0075] FIG. 70 is a simplified side view of the support section of FIG. 69;
- [0076] FIGS. 71-74 are simplified sectional views of various embodiments of a support section similar in some respects to the support section of FIG. 55, where the sectional views are similar to the view of FIG. 56;
- [0077] FIG. 75 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in communication with a weighing system;

[0078] FIGS. 76-77 are simplified side views of at least one embodiment of a support section for the person support apparatus of FIG. 53, showing a lateral tilt position and a substantially flat position, respectively;

[0079] FIG. 78 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;

[0080] FIGS. 79-80 are simplified side views of the support section of FIG. 78, showing a lateral tilt position and a substantially flat position, respectively;

[0081] FIG. 81 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;

[0082] FIG. 82 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;

[0083] FIGS. 83-85 are simplified side views of the support section of FIG. 82, showing a lateral tilt position, another lateral tilt position, and a substantially flat position, respectively;

[0084] FIG. 86 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position, and including at least one side member;

[0085] FIG. 87 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position, and including a side member;

[0086] FIG. 88 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position, and including at least one side member;

[0087] FIG. 89 is a simplified perspective view of the person support apparatus of FIG. 88, shown in a substantially flat position;

[0088] FIG. 90 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;

[0089] FIG. 91 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position;

[0090] FIGS. 92-93 are simplified side views of the support section of FIG. 91, showing a lateral tilt position and a substantially flat position, respectively;

[0091] FIG. 94 is a simplified perspective view of at least one embodiment of the person support apparatus of FIG. 53, shown in a progressive lateral tilt position, and including at least two side members; and

[0092] FIG. 95 is a simplified flow diagram of a method for controlling lateral angles of a person support apparatus.

#### DETAILED DESCRIPTION OF THE DRAWINGS

[0093] While the present disclosure can take many different forms, for the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiments illustrated in the drawings, and specific language will be used to describe the same. No limitation of the scope of the disclosure is thereby intended. Various alterations, further modifications of the described embodiments, and any further applications of the principles of the disclosure, as described herein, are contemplated.

[0094] An adverse event mitigation system 10 according to one contemplated embodiment is shown in Figs. 1-8. The adverse event mitigation system 10 is configured to help reduce the likelihood of an adverse event occurring and/or stop an adverse event in progress. In some contemplated embodiments, the adverse event mitigation system 10 may help reduce the likelihood of obstructive sleep apnea occurring and/or may help stop an obstructive apnea event in progress. In other contemplated embodiments, the adverse event mitigation system 10 may help reduce the likelihood of other adverse events occurring and/or stop other adverse events in progress.

[0095] The adverse event mitigation system 10 includes a person support apparatus 12, a person support surface 14 supported on the person support apparatus 12, and a control system 16 as shown in Fig. 1. In some contemplated embodiments, the person support apparatus 12 is a hospital bed frame and the person support surface 14 is supported thereon as shown in Fig. 2. In other contemplated embodiments, the person support apparatus 12 can be a stretcher, an operating room table, or other person supporting structure. The person support apparatus 12 includes a lower frame 17, supports 18 or lift mechanisms 18 coupled to the lower frame 17, and an upper frame 20 movably supported above the lower frame 17 by the supports 18 as shown in Fig. 1. The lift mechanisms 18 are configured to raise and lower the upper frame 20 with respect to the lower frame 17 and move the upper frame 20 between various orientations, such as, Trendelenburg and reverse Trendelenburg.

[0096] The upper frame 20 includes an upper frame base 24, a deck 26 coupled to the upper frame base 24, and a plurality of actuators 27 coupled to the upper frame base 24 and the deck 26 as shown in Fig. 2. The plurality of actuators 27 are configured to move at least a portion of the deck 26 along at least one of a longitudinal axis, which extends along the length

of the upper frame 20, and a lateral axis, which extends across the width of the upper frame 20, between various articulated configurations with respect to the upper frame base 24. The deck 26 includes a calf section 28, a thigh section 30, a seat section 32, and a head and torso section 34 as shown in Fig. 3. The calf section 28 and the thigh section 30 define a lower limb support section LL1. The head and torso section 34 define an upper body support section U1. The seat section 32 defines the seat section S1. The calf section 28, the thigh section 30, and the seat section 32 define a lower body support section LB1. At least the calf section 28, the thigh section 30, and the head and torso section 34 are movable with respect to one another and/or the upper frame base 24. In some contemplated embodiments, the calf section 28, the thigh section 30, the seat section 32, and the head and torso section 34 cooperate to move the person support apparatus 12 between an substantially planar or lying down configuration and a chair configuration. In some contemplated embodiments, the calf section 28, the thigh section 30, the seat section 32, and the head and torso section 34 cooperate to move the person support apparatus 12 between a substantially planar or lying down configuration and an angled or reclined configuration. In some contemplated embodiments, the head and torso section 34 is moved such that it is at an angle of at least about  $30^\circ$  with respect to a reference plane RP1 passing through the upper frame 20.

[0097] The person support surface 14 is configured to support a person thereon and move with the deck 20 between the various configurations. In some contemplated embodiments, the person support surface 14 is a hospital bed mattress as shown in Fig. 2-4. In some contemplated embodiments, the person support surface 14 is a consumer mattress. In some contemplated embodiments, the person support surface 14 includes a heat and moisture regulating topper positioned on the person support surface 14. In some contemplated embodiments, the person support surface 14 can include a pressure mapping topper positioned on the person support surface 14. The person support surface 14 includes a calf portion 36, a thigh portion 38, a seat portion 40, and a head and torso portion 42 as shown in Fig. 3, which is supported on corresponding sections of the deck 26. In one illustrative embodiment, the deck sections help move and/or maintain the various portions of the person support surface 14 at angles  $\alpha$ ,  $\beta$  and  $\gamma$  with respect to the reference plane RP1. In some contemplated embodiments, the person support surface 14 is a non-powered (static) surface. In some contemplated embodiments, the person support surface 14 is a powered (dynamic) surface configured to receive fluid from a fluid supply FS1 as shown in Fig. 5.

**[0098]** The person support surface 14 includes a mattress cover 44 and a mattress core 46 as shown in Figs. 3 and 4. In some contemplated embodiments, the person support surface 14 includes a temperature and moisture regulating topper (not shown) coupled to the mattress cover 44. The mattress cover 44 encloses the mattress core 46 and includes a fire barrier 48, a bottom ticking 50 or durable layer 50, and a top ticking 52. In some contemplated embodiments, the fire barrier 48 is the innermost layer of the cover 44, the top ticking 52 is the outermost layer, and the bottom ticking 50 is positioned between the fire barrier 48 and the top ticking 52 and is not coupled to the top ticking 52. The bottom ticking 50 and the top ticking 52 are vapor and air impermeable. In some contemplated embodiments, the top ticking 52 and the bottom ticking 50 are composed of polyurethane coated nylon and the bottom ticking 50 is configured to facilitate movement of the top ticking 52 with respect to the fire barrier 48. In other contemplated embodiments, the top ticking 52 and/or the bottom ticking 50 can be air and/or moisture permeable.

**[0099]** The mattress core 46 can be composed of a single type of material or a combination of materials and/or devices. In the case of a powered surface, the mattress core 46 includes at least one fluid bladder 54 therein that receives fluid from a fluid supply (not shown) to maintain the fluid pressure within the fluid bladder 54 at a predetermined level. In some contemplated embodiments, the powered surface can include non-powered components, such as, a foam frame that at least one fluid bladder 54 is positioned between. In some contemplated embodiments, a fluid bladder 54 can be positioned proximate to the thigh section and inflated or the calf portion 36, thigh portion 38, and/or seat portion 40 (including their corresponding deck sections) can be articulated to help prevent the occupant from sliding down the person support surface 14 as, for example, the inclination of the head and torso section 34 increases with respect to the reference plane RP1. In some contemplated embodiments, wedge shaped bladders are mirrored laterally about the centerline of the person support surface 14 and are configured to be inflated consecutively to laterally tilt the occupant, thereby relieving pressure on various portions of the occupant's body to help reduce the occurrences of pressure ulcers.

**[00100]** In some contemplated embodiments, the mattress core 46 includes inflatable fluid bladders 54a and 54b, which are configured to protrude from the patient facing surface of the person support surface 14 by at least about 70 mm (adjusted for pillow height) and about 20 mm to about 30 mm to support the cervical vertebrae and scapula, respectively. In some contemplated embodiments, the inflatable fluid bladders 54a and 54b are replaced foam bolsters or static air bladders or a combination thereof. In some contemplated embodiments, the distance

the fluid bladders 54a and 54b protrude from the patient facing surface of the person support surface 14 can vary depending on any number of factors, including, but not limited to, a person's body type and the angle at which the surface is at with respect to the reference plane RP1. In some contemplated embodiments, the fluid bladders 54a and 54b can also be configured to laterally tilt the head and/or torso of the occupant. In some contemplated embodiments, wedge shaped fluid bladders (not shown) are positioned in the head and torso portion 42 and are configured to increase the angle of the occupant contacting surface of the head and torso portion 42 with respect to the seat portion 40 when inflated.

**[00101]** In some contemplated embodiments, the head and torso of the occupant can be tilted at different angles. For example, the person support apparatus 12 and/or the person support surface 14 can laterally rotate the occupant so that the torso is at an angle of about 10° with respect to the reference plane RP1 and the head is at an angle of about 180° with respect to the reference plane RP1. Rotation of the occupant's torso can help an occupant maintain their head at an angle of about 180° with respect to the reference plane RP1. In some contemplated embodiments, the person support surface 14 is configured to allow the occupant's body to be immersed into the surface to improve comfort with lateral positioning. In some contemplated embodiments, support blocks (not shown) can be placed on the surface 14 adjacent to the occupant to help maintain the position of the occupant. In some contemplated embodiments, the person support apparatus 12 and/or person support surface 14 can laterally rotate the occupant so that the torso is at an angle of about 10° with respect to the reference plane RP1 and fluid bladders 54a and 54b can rotate the occupant's head so that it is at an angle of at least about 180°. In some contemplated embodiments, the occupant can be wearing a garment G1 with fluid bladders G2 configured to be inflated to help laterally rotate the occupant so that the torso is at an angle of at least 10° with respect to the reference plane RP1 as shown in Fig. 9. In some contemplated embodiments, the garment G1 is configured to provide therapy, including, for example, percussion, vibration, and compression therapies. In some contemplated embodiments, the garment G1 is an airway clearance vest, such as the Vest® Airway Clearance System sold by Hill-Rom. In other contemplated embodiments, the garment G1 can be other therapy garments, including sequential compression devices (SCD). In some contemplated embodiments, fluid can be supplied to the garment G1 via the fluid supply FS1 configured to supply fluid to the fluid bladders 54a and 54b. In some contemplated embodiments, fluid is supplied to the garment G1 and/or fluid bladders G2 by a dedicated fluid supply (not shown).

The angle of the occupant's head with respect to the reference plane RP1 may vary depending on the occupant's preferences, their risk of the adverse condition, or other factors.

**[00102]** In the case of a non-powered surface, the mattress core 46 is composed of a cellular engineered material, such as, single density foam. In some contemplated embodiments, the mattress core 46 includes at least one bladder 54, such as, a static air bladder or a static air bladder with foam contained there within, a metal spring and/or other non-powered support elements or combinations thereof. In some contemplated embodiments, the mattress core 46 includes multiple zones with different support characteristics configured to enhance pressure redistribution as a function of the proportional differences of a person's body. Also, in some embodiments, the mattress core 46 includes various layers and/or sections of foam having different impression load deflection (ILD) characteristics, such as, in the NP100 Prevention Surface, AccuMax Quantum™ VPC Therapy Surface, and NP200 Wound Surfaces sold by Hill-Rom®.

**[00103]** The control system 16 is configured to change at least one characteristic of the person support apparatus 12 and/or person support surface 14 to help reduce the likelihood of an adverse event occurring and/or stop an adverse event in progress. The control system 16 includes a processor 100, an input 102, and memory 104. In some contemplated embodiments, the input 102 includes a sensor 106, such as, a position sensor, a pressure sensor, a temperature sensor, an acoustic sensor, and/or a moisture sensor, configured to provide an input signal to the processor 100 indicative of a physiological characteristic of the occupant, such as, the occupant's heart rate, respiration rate, respiration amplitude, skin temperature, weight, and position. In some contemplated embodiments, the sensors 106 are incorporated into the person support surface 14 or topper positioned on the person support surface, for example, as disclosed in U.S. Patent No. 7,515,059 to Price *et al.* and U.S. Patent Publication No. 2011/0068928 to Riley *et al.* In some contemplated embodiments, the sensors 106 include, for example, RFID tags, accelerometers, proximity sensors, level sensors, or other physical tracking sensors that may be integrated into or coupled to, for example, ear plugs, ear phones, adhesive sensors, earlobe clips, eye covers, hats, nose strips or other devices that are attached to the patient's head or worn by the patient so that the position/orientation of the patient's head can be tracked. Information captured by monitoring the lateral position of the user's upper respiratory tract has several benefits, including one or more of the following: providing more accurate measurements of the upper respiratory angle for diagnosis of positional obstructive sleep apnea (in one example, sleep labs can use the information to more accurately diagnose POSA);

providing biofeedback to help the user to train to maintain a posture that prevents POSA; tracking performance of the system to determine if the system is achieving a sufficient upper respiratory angle to prevent apnea; monitoring compliance to determine if the system is being used; monitoring the upper respiratory angle and recording the angle when a sleep apnea event occurs; and controlling a surface capable of providing lateral rotation as a function of the inputs from the sensors 106, tracking whether optimal lateral position has been achieved, and controlling the system to achieve a desired head lateral position and/or upper respiratory angle. In some contemplated embodiments, the sensors 106 are tracked by reading devices (i.e., an RFID reader) in a siderail, person support surface, deck, headboard, or location on or in the person support apparatus 10 or person support surface 14, or on or in a headwall in the room or other location in the room. In some contemplated embodiments, the sensor 106 includes a camera positioned at the foot of the bed or above the bed, as disclosed in U.S. Patent Publication No. 2012/0029879 to Sing *et al.*, for example, to track the orientation of the person's head.

**[00104]** In some contemplated embodiments, the input 102 includes a user interface 108 configured to receive information from a caregiver or other user. In other contemplated embodiments, the input 102 is an Electronic Medical Record (EMR) system 110 in communication with the processor 100 via a hospital network 112. In some contemplated embodiments, the processor 100 can output information, automatically or manually upon caregiver input, to the EMR for charting, which can include therapy initiation and termination, adverse event occurrence information, therapy protocol used, caregiver ID, and any other information associated with the occupant, caregiver, person support apparatus 12, person support surface 14, and adverse event.

**[00105]** The memory 104 stores one or more instruction sets configured to be executed by the processor 100. The instruction sets define procedures 114 that, when executed by the processor, cause the processor 100 to implement one or more protocols that modify the configuration of the person support apparatus 12 and/or the person support surface 14. In one illustrative embodiment, the instruction set defines a proactive procedure 114 that causes the processor 100 to configure the person support apparatus 12 and/or the person support surface 14 in response to an input specifying that the occupant is at risk for sleep apnea. Procedure 114 begins with step 116 in which the processor 100 receives an input signal from the input 102 indicative of the level of risk for an apnea event occurring. In some contemplated embodiments, the level of risk is input from a field in the occupant's EMR. In some contemplated

embodiments, the level of risk is input by a caregiver through the user interface 108, which may arise from a doctor's order or be based on a patient scoring system. In some contemplated embodiments, the level of risk is determined based on a risk score that is calculated by the processor 100 based on a number of factors, including, but not limited to, those listed in the table below:

|                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Predisposing physical characteristics               | <ul style="list-style-type: none"> <li>• BMI in the 95th percentile for age and gender (i.e., 35 kg/m<sup>2</sup>)</li> <li>• 17 inch neck circumference for men (16 inches for women)</li> <li>• craniofacial abnormalities that affect the airway</li> <li>• anatomical nasal obstructions</li> <li>• tonsils that nearly touch or do touch in the midline</li> </ul>                                                                                                                  |
| History of apparent airway obstruction during sleep | <ul style="list-style-type: none"> <li>• loud or frequent snoring</li> <li>• observed pauses in breathing while asleep</li> <li>• awakening from sleep with a choking sensation</li> <li>• frequent arousal from sleep</li> </ul>                                                                                                                                                                                                                                                        |
| Somnolence                                          | <ul style="list-style-type: none"> <li>• frequent somnolence or fatigue despite getting an adequate amount of sleep</li> <li>• falling asleep easily in a nonstimulating place despite adequate sleep</li> </ul>                                                                                                                                                                                                                                                                         |
| Sleep study results                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Invasiveness of surgery and anesthesia              | <ul style="list-style-type: none"> <li>• superficial under local or peripheral nerve block without sedation</li> <li>• superficial with moderate sedation or general anesthesia</li> <li>• peripheral with spinal or epidural anesthesia and no more than moderate sedation</li> <li>• peripheral with general anesthesia</li> <li>• airway surgery with moderate sedation</li> <li>• major surgery with general anesthesia</li> <li>• airway surgery with general anesthesia</li> </ul> |
| Requirement of postoperative opioids                | <ul style="list-style-type: none"> <li>• none</li> <li>• low-dose oral opioids</li> <li>• high-dose oral opioids or neuraxial or parenteral opioids</li> </ul>                                                                                                                                                                                                                                                                                                                           |
| Estimation of perioperative risk                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Sex and age of occupant                             | <ul style="list-style-type: none"> <li>• Estimated sleep disordered breathing is 9% in women and 24% in men with the prevalence for obstructive sleep apnea being 2% in women and 4% in men. The percentages likely increase for older and more obese people</li> </ul>                                                                                                                                                                                                                  |

**[00106]** In circumstances where an occupant is known to snore frequently, has a high BMI, has had major surgery, and/or requires postoperative opioids, the occupant may have an

elevated risk. In circumstances where an occupant has a low BMI, is not known to snore, had superficial surgery, and/or does not require postoperative opioids, the occupant may have a reduced risk. An example of a scoring system is shown in the table below, where a score of 4 can indicate an increased risk, and a score of greater than 4 can indicate a significantly increased risk.

|                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                      |
|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| I. Severity of apnea                                                    | <ul style="list-style-type: none"> <li>Based on sleep study</li> <li>Based on predisposing physical characteristics, history of apparent airway obstruction during sleep, and somnolence <ul style="list-style-type: none"> <li>None</li> <li>Mild</li> <li>Moderate</li> <li>Severe</li> </ul> </li> </ul>                                                                                                                                                                                                                                              | 0-3 points<br><br><br>0 points<br>1 point<br>2 points<br>3 points                                    |
| II. Surgery and Anesthesia                                              | <ul style="list-style-type: none"> <li>Invasiveness</li> <li>Type <ul style="list-style-type: none"> <li>Superficial under local or peripheral nerve block without sedation</li> <li>Superficial with moderate sedation or general anesthesia</li> <li>Peripheral with spinal or epidural anesthesia and no more than moderate sedation</li> <li>Peripheral with general anesthesia</li> <li>Airway surgery with moderate sedation</li> <li>Major surgery with general anesthesia</li> <li>Airway surgery with general anesthesia</li> </ul> </li> </ul> | 0-3 points<br><br><br>0 points<br>1 point<br>1 point<br>2 points<br>2 points<br>3 points<br>3 points |
| III. Postoperative opioids                                              | <ul style="list-style-type: none"> <li>Requirement</li> <li>Dosage <ul style="list-style-type: none"> <li>None</li> <li>Low-dose oral</li> <li>High dose oral, parenteral or neuraxial</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                                                            | 0-3 points<br><br><br>0 points<br>1 point<br>3 points                                                |
| Risk = Score from I + Score from the greater of II and III (0-6 points) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                      |

**[00107]** In step 118, the processor 100 determines which protocol should be implemented based on the level of risk. One type of the protocol is a default protocol set according to the

hospital's standard operating procedures/guidelines for patients with specific risk profiles. Another type of protocol is a variable protocol that modifies the default protocol based on the occupant's preferences (i.e., prefers to sleep on their left side), the caregiver's observations, and/or information about the occupant's medical condition (i.e., pressure ulcer susceptibility, BMI, type of surgery, etc.) from the occupant's EMR, sensors 106, and/or other input 102. In some contemplated embodiments, the protocol can be modified to exclude or limit a therapy or movement. For example, the protocol can be prevented from increasing the head of bed angle (the angle between the reference plane RP1 and the head and torso section 34 or head and torso portion 42) above a predetermined threshold where the occupant is recovering from abdominal surgery. In some contemplated embodiments, the protocol can caution the caregiver against implementing the configurations based on information obtained from the occupant's EMR or other sources.

[00108] In step 120, once the protocol is selected, the configuration settings are communicated to the caregiver, for example, on a graphical user interface or other display device, and the caregiver is prompted to accept/modify the settings. In some contemplated embodiments, the configuration settings can be communicated to a hand held device. In one example, the protocol may require the head of bed angle to be greater than about 35° and the lateral tilt angle to be greater than 15° with respect to the reference plane RP1 for an occupant with an elevated risk score. In another example, the protocol may require the head of bed angle to be about 10° to about 15° and the lateral tilt angle to be about 10° to about 15° with respect to the reference plane RP1 for an occupant with a reduced risk score. In some contemplated embodiments, the upper frame 20 can also be moved to a Trendelenburg or reverse Trendelenburg orientation. In some contemplated embodiments, the protocol can require additional therapies to be active, such as, continuous lateral rotation where, for example, the lateral tilt angle changes every 30-120 minutes depending on the occupant's risk of developing pressure ulcers. In some contemplated embodiments, the sleep stage of the occupant can be taken into account so that the occupant is moved only when they are in a sleep state that would allow them to be moved without waking up. In some contemplated embodiments, the person support apparatus 12 and/or the person support surface 14 are returned to the configuration they were in prior to the implementation of the protocol before the occupant wakes up. In some contemplated embodiments, a manual stop button can be included so that the caregiver, occupant, or other person can terminate the protocol in the event of an emergency. In some contemplated embodiments, the protocol can automatically be terminated when an emergency

condition occurs, such as, when the CPR handle (not shown) is pulled by a caregiver or the occupant is coding. In some contemplated embodiments, the procedure 114 can be terminated remotely by a caregiver, such as, via the hospital network or over a nurse call system.

[00109] In some contemplated embodiments, the position and/or the orientation of the occupant with respect to patient facing surface of the person support surface 14 is detected and can influence how the person support surface 14 and/or the person support apparatus 12 are configured to move the occupant to the desired position. For example, if the occupant is positioned along the left edge of the patient facing surface of the person support surface 14, the protocol will not rotate them to the left. In some contemplated embodiments, the protocol is terminated because the occupant is in the correct position. In some contemplated embodiments, the protocol helps to maintain the occupant in the position. The position of the occupant on the person support surface 14 can be determined a number of ways, including sensing the force distribution on the upper frame 20 utilizing one or more load cells (not shown) coupled to the upper frame 20, calculating the occupant's center of gravity using the one or more load cells, sensing pressures within the fluid bladders 54, using a camera (not shown) or 3D sensor (not shown), or using other methods.

[00110] In step 122, if the caregiver accepts the configuration or changes the configuration and accepts the new configuration, the processor 100 implements the configuration for a predetermined time. In some contemplated embodiments, the processor 100 can implement the configuration the moment the caregiver approves it and stop or change the configuration when the caregiver deactivates it. In some contemplated embodiments, the processor 100 will wait to implement the configuration until the occupant is in a predetermined sleep stage and will return to the initial configuration when the occupant begins to wake up. In some contemplated embodiments, procedure 114 does not require the caregiver to confirm or accept the settings, and instead automatically initiates the configuration. For example, the configuration can be automatically initiated a predetermined time after the occupant departed from the surgical room, which can be determined based on the occupant's EMR. In some contemplated embodiments, the configuration will not be implemented if the bed is unoccupied.

[00111] Procedure 114 can be used for a number of other adverse conditions. In some contemplated embodiments, procedure 114 can be used to determine if a person is at risk for or has gastroesophageal reflux disease and select a protocol that assists the occupant in maintaining a left lateral decubitus position or semi-reclining position while sleeping. In some contemplated embodiments, procedure 114 can be used to determine if a person is at risk for or

has chronic respiratory insufficiency and select a protocol for the caregiver to approve that assists the occupant in maintaining a left lateral decubitus position while sleeping. In some contemplated embodiments, the procedure can be used to determine if a person is at risk for or has allergies to, for example, feather or down filled pillows, cushions or covers, and can alert the caregiver so that they can remove the item. In other contemplated embodiments, procedure 114 can be used to determine if the person is at risk for or has one or more other conditions, such as, for example, asthma, pregnancy, sleep paralysis or hallucinations, snoring, stroke bruxism, coughing, hypoxaemia in geriatric inpatients, stroke, or tuberculosis, that might be affected negatively by sleeping in the supine position and select a protocol and/or alert the caregiver so that the person support apparatus 12 and/or the person support surface 14 can be configured to maintain the occupant in a desirable position. In some contemplated embodiments, the procedure 114 can be used to change the sleeping position of occupants to help stimulate blood oxygenation, which can undesirably decrease as the occupant remains stationary.

**[00112]** In another illustrative embodiment, the instruction set causes the processor 100 to carry out a responsive procedure 114 that configures the person support apparatus 12 and/or the person support surface 14 in response to detection of an adverse event, such as, an apnea event. Procedure 124 begins with step 126 where the adverse event mitigation system is armed manually by the caregiver or automatically based on information from the occupant's EMR, the caregiver, or calculated by the processor 100.

**[00113]** In step 127, the processor 100 receives signals from the sensors 106 indicative of the physiological characteristics of the occupant, including, but not limited to, the occupant's heart rate and the respiration characteristics, such as, amplitude and rate, and/or the amount of movement of the occupant.

**[00114]** In step 128, the processor 100 compares the signals from the sensors 106 to predetermined thresholds to determine if an apnea event is in progress. For example, if there is an interval of at least about 10 seconds between breaths then the person is likely having an apnea event. In another example, if the person is taking less than about 25% of a normal breath for at least about 10 seconds, then the person is likely having an apnea event. In another example, if there is a drop in oxygen saturation of at least about 4%, then the person is likely having an apnea event. If the person is taking between about 26% and about 69% of a normal breath, the person is likely having a hypopnea event. In some contemplated embodiments, the processor 100 determines that an adverse event is in progress and alerts the caregiver that an

adverse event is occurring and that it is likely not an apnea event based on the position of the occupant and/or the configuration of the person support apparatus 12 and/or the person support surface 14, the occupant's risk score, and/or the occupant's physiological characteristics, medical information from the occupant's EMR, and/or other information. In some contemplated embodiments, the caregiver can be alerted by a visual or audible alarm on the person support apparatus 12, a visual or audible alarm located in the room where the person support apparatus 12 is located, and/or a visual or audible alarm located proximate to the room, such as, in the hall way.

**[00115]** In some contemplated embodiments, the caregiver can be notified remotely by a communication system (not shown). In some contemplated embodiments, the communication system is a patient/nurse call system that can include patient stations capable of generating hospital calls and a remote master station which can prioritize and store the calls. One example of such a system is disclosed in U.S. Patent No. 5,561,412 issued on October 1, 1996 to Novak *et al.*, which is incorporated by reference herein in its entirety. Another example of such a system is disclosed in U.S. Patent No. 4,967,195 issued on May 8, 2006 to Shipley, which is incorporated by reference herein in its entirety.

**[00116]** In another contemplated embodiment, the communication system is a system for transmitting voice and data in packets over a network with any suitable number of intra-room networks that can couple a number of data devices to an audio station, where the audio station couples the respective intra-room network to a packet based network. One example of such a system is disclosed in U.S. Patent No. 7,315,535 issued on January 1, 2008 to Schuman, which is incorporated by reference herein in its entirety. Another example of such a system is disclosed in U.S. Patent Publication No. 2008/0095156 issued on April 24, 2008 to Schuman, which is incorporated by reference herein in its entirety.

**[00117]** In yet another contemplated embodiment, the communication system includes a patient/nurse call system, a nurse call/locating badge, an electronic medical record (EMR) database, and one or more computers programmed with work-flow process software. One example of such a system is disclosed in U.S. Patent Publication No. 2008/0094207 published on Apr. 24, 2008 to Collins, Jr. *et al.*, which is incorporated by reference herein in its entirety. Another example of such a system is disclosed in U.S. Patent Publication No. 2007/0210917 published on September 13, 2007 to Collins, Jr. *et al.*, which is incorporated by reference herein in its entirety. Yet another example of such a system is disclosed in U.S. Patent No. 7,319,386 published on January 15, 2008 to Collins, Jr. *et al.*, which is incorporated by reference herein in

its entirety. It should be appreciated that the work-flow process software can be the NaviCare® software available from Hill-Rom Company, Inc. It should also be appreciated that the work-flow process software can be the system disclosed in U.S. Patent No. 7,443,303 issued on October 28, 2008 to Spear *et al.*, which is incorporated by reference herein in its entirety. It should further be appreciated that the badge can be of the type available as part of the ComLinx™ system from Hill-Rom Company, Inc. It should also be appreciated that the badge can also be of the type available from Vocera Communications, Inc.

[00118] In still another contemplated embodiment, the communication system is configured to organize, store, maintain and facilitate retrieval of bed status information, along with the various non-bed calls placed in a hospital wing or ward, and remotely identify and monitor the status and location of the person support apparatus, patients, and caregivers. One example of such a system is disclosed in U.S. Patent No. 7,242,308 issued on July 10, 2007 to Ulrich *et al.*, which is incorporated by reference herein in its entirety. It should be appreciated that the remote status and location monitoring can be the system disclosed in U.S. Patent No. 7,242,306 issued on July 10, 2007 to Wildman *et al.*, which is incorporated by reference herein in its entirety. It should also be appreciated that the remote status and location monitoring can be the system disclosed in U.S. Patent Publication No. 2007/0247316 published on October 25, 2007 to Wildman *et al.*, which is incorporated by reference herein in its entirety.

[00119] In step 130, if the processor determines an apnea event is in progress, the processor 100 configures the person support surface 14 and/or the person support apparatus 12 to intervene and help stop the apnea event. In one illustrative embodiment, the processor 100 inflates a bladder 54 in the person support surface 14 to rotate the occupant onto their side such that they are at an angle of about 10° with respect to the reference plane RP1. In some contemplated embodiments, the upper frame 20 can be rotated along the longitudinal axis to laterally tilt the occupant. In another illustrative embodiment, the processor 100 increases the head of bed angle to about 15° by moving the head and torso section 34 of the person support apparatus 12 and/or inflating a bladder 54 in the person support surface 14. In some contemplated embodiments, the processor 100 increases the head of bed angle and laterally rotates at least a portion of the occupant's body. In some contemplated embodiments, the processor 100 implements additional therapies, such as, for example, continuous lateral rotation therapy (CLRT), percussion vibration therapy, heat and moisture management therapy, rotation therapy, or other therapies depending on the occupant's risk for developing additional adverse conditions, such as, pressure ulcers.

**[00120]** In some contemplated embodiments, procedure 124 includes step 132 and step 134 in which the processor 100, after implementing the intervention, receives signals from the sensors 106 indicative of the occupant's physiological characteristics and/or the amount of movement of the occupant, and compares them with the predetermined thresholds to determine if the intervention was successful and the apnea event has ceased. In one illustrative embodiment, the processor 100 waits a predetermined amount of time, such as, 5 seconds, after the intervention has been implemented before it receives signals from the sensors 106. In some contemplated embodiments, the processor 100 can receive signals from the sensors 106 as the intervention is implemented and stop intervening or maintain the current level of intervention when the apnea event has ceased. For example, the processor 100 receives signals from the sensors 106 as the head of bed angle and/or the lateral tilt angle are gradually increased and stops increasing the head of bed angle and/or the lateral tilt angle once the apnea event has ceased. In some embodiments, the head of bed angle and/or the lateral tilt angle are gradually increased and an alarm is activated when the angle reaches a predetermined threshold. If the processor 100 determines that the intervention was successful, the processor 100 can cause the person support apparatus 12 and/or the person support surface 14 to maintain the current configuration or cause it to return to its initial position.

**[00121]** If the processor 100 determines that the apnea event is still in progress, the processor 100 can increase the level of intervention. In one illustrative embodiment, the head of bed angle and/or the lateral tilt angle can be increased an additional 5°. In other embodiments, the stimuli can include vibration, sound, temperature, smells, lights (flashing and/or constant), or other stimulus or combinations thereof that may or may not wake the person. In some instances, the goal of the intervention is to stop the apnea event without waking the occupant up, which can include moving the person while the person is in a particular sleep stage and/or causing the person to move from a deeper sleep stage to a lighter sleep stage. In some contemplated embodiments, movement of the occupant can cease if the processor 100 detects the person is waking up (based on increased heart rate, respiration rate, and/or movement) or is moving to a lighter sleep stage. If the increased levels of intervention continue to be unsuccessful then the processor 100 can initiate an alarm on or near the person support apparatus 12 to wake the occupant and/or notify a caregiver via nurse call or other means of communication that they need to intervene. In some contemplated embodiments, if the processor 100 receives information that the occupant is sedated, the processor 100 can move the occupant to a position, such as, for example, a sitting position or chair position.

**[00122]** In another illustrative embodiment, the instruction set causes the processor 100 to carry out a proactive procedure 136 that configures the person support apparatus 12 and/or the person support surface 14 when the processor 100 predicts the onset of an adverse event. Procedure 136 begins with step 138 where the system for mitigating adverse conditions is armed by the caregiver or the bed or EMR based on the occupant's risk profile.

**[00123]** In step 139, the processor 100 receives signals from the sensors 106 indicative of the physiological characteristics of the occupant and/or the amount of movement of the occupant.

**[00124]** In step 140, the processor 100 stores the signal values in the memory 104 and determines an amount and/or a magnitude of change in the values for a predetermined time period. The processor 100 then compares the amount and/or the magnitude of change to a predetermined threshold to determine if an adverse event is likely to occur. In some contemplated embodiments, the processor 100 considers other factors, such as, the occupant's risk score, body position or orientation, person support apparatus 12 and/or person support surface 14 configurations, medical conditions, and/or other information from the caregiver, occupant's EMR, sensors 106, and/or person support apparatus 12 and/or person support surface 14 when determining the likelihood of an adverse event occurring. For example, if an occupant is at a high risk for apnea, is in the supine position, and the occupant's respiration rate is decreasing, then an apnea event may occur. In another example, if an occupant's respiration amplitude decreases and the occupant's oxygen saturation decreases then an apnea event may occur. In another example, if an occupant's snoring is very loud and the occupant is at a high risk for apnea, an apnea event may occur. In another example, if an occupant is at high risk and the occupant is receiving 90% normal breath, an apnea event may be unlikely.

**[00125]** In some contemplated embodiments, prediction of an apnea event can be accomplished using a time-domain model of nonlinear time-lagged interactions between heart rate, respiration, and oxygen saturation to help determine when an apnea event is likely. In some contemplated embodiments, prediction of an apnea event can be accomplished using a Bayesian "belief network" model. In some contemplated embodiments, prediction of an apnea event can be accomplished using large memory storage and retrieval (LAMSTAR) artificial neural networks to analyze signals indicative of heart rate variability, nasal pressure, oronasal temperature, submental EMG, and electrooculography. In some contemplated embodiments, prediction of an apnea event can be accomplished by analyzing tracheal breath sounds.

[00126] In step 142, the processor configures the person support surface 14 and/or the person support apparatus 12 as previously described above with respect to procedure 114 and procedure 124 to intervene and help prevent the apnea event.

[00127] In another contemplated embodiment, referring to FIGS. 11-18, a support system includes one or more support pieces or units that form a lateral support plane to prevent or restrict the user from sleeping in a supine position, and, more specifically, reduce a time duration that the user sleeps with his/her upper respiratory tract oriented vertically or at an undesirable lateral rotational angle with respect to a vertical plane substantially perpendicular to a horizontal plane. In certain embodiments, the lateral rotational angle of the user's head with respect to the vertical plane is at least 30 degrees and, more specifically, at least 45 degrees. In an alternative embodiment, the lateral rotational angle of the user's head with respect to the vertical plane may be less than 30 degrees. In one embodiment, the support pieces provide multiple support planes for supporting the user's body.

[00128] In one embodiment as shown in FIGS. 11-18, a support system 1100 suitable for supporting a user, such as a person, for example, includes plurality of support pieces, namely a first or leg support piece 1102 forming a first support plane 1104, a second or torso support piece 1106 forming a second support plane 1108, and a third or head support piece 1110 forming a third support plane 1112 that collectively define a segmented, multi-plane, laterally angled sleep surface 1114 having progressively greater angles of rotation along a longitudinal axis 1115 of support system 1100, from a first or bottom edge 1116 of sleep surface 1114 to an opposing second or top edge 1118 of sleep surface 1114, resulting in relatively greater rotation of the upper respiratory tract of the user (as necessary for efficacy in preventing obstructive apnea) and relatively lesser rotation in the lower body of the user (resulting in greater comfort and perceived stability by avoiding rotation of a majority of the user's body mass). In alternative embodiments, sleep surface 1114 is formed using any suitable number of support pieces defining corresponding support planes, for example, one support piece forming a smooth contour over a length of sleep surface 1114 from first edge 1116 to opposing second edge 1118 or a plurality of support pieces, such as two support pieces, three support pieces, or more than three support pieces forming a smooth contour over the length of sleep surface 1114.

[00129] Unlike conventional positional therapies for the prevention of obstructive sleep apnea, which attempt to manipulate the user's sleep position and/or orientation using rotation of one plane, in certain embodiments the system described herein uses multiple support planes formed by one or more support pieces to laterally rotate the user. For example, in one

embodiment, two support pieces provide two separate support planes, with a first support plane defined by the first support piece configured to support the torso and the legs of the user, and a second support plane defined by the second support piece configured to support the neck and the head of the user.

**[00130]** In an alternative embodiment, three support pieces provide three separate support planes, with a first support plane defined by the first support piece configured to support the legs of the user, a second support plane defined by the second support piece configured to support the torso of the user, and a third support plane defined by the third support piece configured to support the head of the user.

**[00131]** In a further alternative embodiment, more than three support pieces, for example, numerous independent support pieces having a length in a longitudinal direction of sleep surface 1114 of 2-18 inches or, more specifically, 4-12 inches, or, even more specifically, 6 inches, provide a corresponding number of separate support planes. Each support piece can be laterally rotated independently of other support pieces to collectively form sleep surface 1114. In a particular embodiment, the numerous support pieces can be combined to form separate support pieces, for example, creating a first support piece having a length of 18 inches in the longitudinal direction at the foot of the support system 1100, an adjacent second support piece having a length of 12 inches in the longitudinal direction, and a third support piece adjacent the second support piece having a length in the longitudinal direction of 6 inches. In these embodiments, the support pieces forming the support planes can be rotated as necessary or desired to achieve an optimal configuration that is clinically effective (i.e., prevents apnea) and demonstrates acceptable tolerance (i.e., allows the user to sleep comfortably). In an alternative embodiment, a continuously sloped sleep surface is formed by a plurality of support pieces without step increases in lateral rotational angle; this is illustrated as a sleep surface with an infinite number of support pieces.

**[00132]** In the embodiments described herein, the length in the longitudinal direction of each support piece and defined support plane (and the resulting location of transitions between support planes) is designed to achieve clinical efficacy and tolerability. Therefore, a specific length can be defined in a number of configurations, including without limitations: (a) generic plane dimensions (e.g., based on average body geometry, a length of a torso section of the user defined so that when an average user's head is supported by a head support piece, a transition between the torso support piece and the leg support piece occurs below the user's S3 vertebrae); (b) customized plane dimensions (e.g., a torso support plane has a suitable length in the

longitudinal direction appropriate to the user's leg length, torso length, and/or a distance from the user's shoulder to his/her inseam); or (c) dynamic plane dimensions (e.g., transitions selected on dynamic surface appropriate to user, selection being either user-selected, care-giver defined, or automatically calculated).

**[00133]** In certain embodiments, each support piece defining the corresponding support planes is independently rotatable about an axis extending parallel with a longitudinal axis of the support system. The independent rotation of each support piece allows the caregiver or the user the ability to focus on progressively increasing an angle of rotation in one or more support pieces having support planes positioned to support the torso of the user, and the neck and/or the head of the user. In certain embodiments, an angle of rotation (or lateral rotational angle) at which the one or more support planes defined by the support pieces configured to support the neck and/or the head of the user is positioned is greater than a rotational angle of the one or more support planes defined by the support pieces configured to support the torso of the user, which is greater than a rotational angle at which the one or more support planes defined by the support pieces configured to support the legs of the user is positioned.

**[00134]** In a particular embodiment, the support plane defined by the support piece configured to support the legs and the torso of the user is positioned at a rotational angle of 10° with respect to a base surface of the support piece, while the support plane defined by the support piece configured to support the head of the user is positioned at a rotational angle of 20° with respect to a base surface of the support piece. In an alternative embodiment, a first support plane defined by the support piece configured to support the legs of the user is positioned at a rotational angle of 10° with respect to a base surface of the first support piece, a second support plane defined by a second support piece configured to support the torso of the user is positioned at a rotational angle of 15° with respect to a base surface of the second support piece, and a third support plane defined by the third support piece configured to support the head of the user is positioned at a rotational angle of 20° with respect to a base surface of the third support piece. In alternative embodiments, the support planes can be positioned at any suitable rotational angle including any suitable lateral rotational angle and/or any suitable longitudinal rotational angle.

**[00135]** Referring further to FIGS. 14 and 15, in a particular embodiment, first support piece 1102 defines support plane 1104 positioned at a lateral rotational angle  $\alpha$  of 20° to 30°, or more specifically, 20° to 25°, or, even more specifically, 25° with respect to a base surface 1122 of first support piece 1102. Second support piece 1106 defines support plane 1108 positioned at

a lateral rotational angle  $\beta$  of  $10^\circ$  to  $20^\circ$ , or more specifically,  $10^\circ$  to  $15^\circ$ , or, even more specifically,  $15^\circ$ , with respect to a base surface 1124 of second support piece 1106. Third support piece 1110 defines support plane 1112 positioned at a lateral rotational angle  $\gamma$  of  $5^\circ$  to  $15^\circ$ , or more specifically,  $10^\circ$ , with respect to a base surface 1126 of third support piece 1106. Other lateral rotational angles and step increases in lateral rotational angles between each support piece may also be used to achieve a progressive lateral rotational angle.

**[00136]** In one embodiment as shown in FIG. 15, one or more contoured transitional pieces, such as a first transitional piece 1130 and a second transitional piece 1132, are positionable between adjacent support pieces or at or near a transition line between the adjacent support pieces to provide a gradual continuous transition between support planes. As shown in FIG. 15, in one embodiment, a first transitional piece 1130 is positioned at a transitional line where first support piece 1102 meets with adjacent second support piece 1106 to provide lumbar support for the user. Similarly, a second transitional piece 1132 is positioned at a transitional line where second support piece 1106 meets with adjacent third support piece 1110 to provide lumbar support for the user. In particular embodiments, one or more additional transitional pieces can be positioned on the support planes to provide additional support at the neck region and/or the knee region of the user, for example. In other embodiments, increasing the number of contoured transitional pieces allows for more contouring and gradual changes in the angle of support along the length of the support system 1100.

**[00137]** As shown in FIG. 17, each of first support piece 1102, second support piece 1106, and third support piece 1110 has a respective height in a direction perpendicular to longitudinal axis 1115 of support system 1100. In one embodiment, first support piece 1102 has a maximum height from base surface 1122 to support plane 1116 in a direction perpendicular to longitudinal axis 1115 of 14 to 18 inches, or more specifically, 16 to 17 inches; second support piece 1106 has a maximum height from base surface 1124 to support plane 1108 in a direction perpendicular to longitudinal axis 1115 of 8 to 12 inches, or more specifically, 9 to 10 inches; and third support piece 1110 has a maximum height from base surface 1126 to support plane 1112 in a direction perpendicular to longitudinal axis 1115 of 4 to 8 inches, or more specifically, 6 to 7 inches. As a result, the support pieces can be designed with desired heights and defining support planes positioned at desired rotational angles such that support system 1100 provides a composite longitudinal plane angle (e.g., reverse Trendelenburg angle) to facilitate the prevention and/or treatment of sleep apnea as well as to improve tolerability.

**[00138]** As described in greater detail below, in certain embodiments, support system 1100 includes a system control, such as a controller 1140 shown in FIG. 18, having a display configured to display information about support system 1100 including, without limitation, lateral plane angles of each support piece and/or composite plane angles of each support piece. In one embodiment, controller 1140 includes one or more processors configured to adjust the rotational angles of the support planes based on data input by the user or a caregiver and/or data signals received from one or more sensors positioned at locations on or near support system 1100.

**[00139]** Referring again to FIG. 15, in one embodiment, support system 1100 includes a bolster 1142 or other suitable boarder positioned along at least one lateral side of support system 1100 to limit or prevent lateral migration of the user. More specifically, bolster 1142 extends along at least a portion of the lateral side generally parallel with longitudinal axis 1115 to prevent or limit lateral movement of the user positioned on sleep surface 1114 to prevent the user from moving or sliding off sleep surface 1114. Bolster 1142 is bolstered at lower edge 1116 of sleep surface 1114 to define an envelopment zone. In one embodiment, bolster 1142 extends from lower edge 1116 partially along a length of support system 1100 to a torso region of the user, but, in this embodiment, terminates below a head portion of the user. In a particular embodiment, at least a portion of bolster 1142 includes a suitable material to provide a textured surface to facilitate retaining the user in the desired position on the support system 1100. Additionally or alternatively, bolster 1142 may include a formable material, such as a suitable foam material, having one or more different densities along a length of bolster 1142 to provide an increased envelopment throughout sleep surface 1114. A belt and/or an adjustable strap (not shown in FIG. 15) or a body may be operatively coupled to bolster 1142 to facilitate maintaining the user properly positioned on sleep surface 1114.

**[00140]** In one embodiment, each of support pieces 1102, 1106, 1110 are rotatable about longitudinal axis 1115 to provide sleep surface 1114 having a right side slope or, alternatively, a left side slope to allow the user to sleep on his/her right side or left side, respectively. In one embodiment, one or more cylindrical or tubular sections are positioned within at least a portion of first support piece 1102, second support piece 1106, and third support piece 1110 and coaxially aligned with longitudinal axis 1115 to allow each support piece 1102, 1106, 1110 to rotate about longitudinal axis 1115 independently of the other support pieces 1102, 1106, 1110.

**[00141]** As shown in FIG. 19, a first cylindrical section 1144 is positioned within a bore 1146 defined within a portion of first support piece 1102 and second support piece 1106 along

longitudinal axis 1115 to allow first support piece 1102 and second support piece 1106 to rotate about longitudinal axis 1115 and with respect to each other. Similarly, a second cylindrical section 1148 is positioned within a bore 1150 defined within a portion of second support piece 1106 and third support piece 1110 along longitudinal axis 1115 to allow second support piece 1106 and third support piece 1110 to rotate about longitudinal axis 1115 and with respect to each other. In an alternative embodiment not shown, a single cylindrical section extends through a bore defined through second support piece 1106 and into at least a portion of first support piece 1102 and into at least a portion of third support piece 1110 to allow each of first support piece 1102, second support piece 1106, and third support piece 1110 to rotate about longitudinal axis 1115 and with respect to each other. In this embodiment, each support piece 1102, 1106, 1110 is rotatable between a first orientation having a right side slope, as shown in FIG. 20A, and a second orientation having a left side slope, as shown in FIG. 20B. Axial rotation allows each support piece 1104, 1106, 1110 to lie flat with a right side slope or a left side slope as shown in FIGS. 20A and 20B.

**[00142]** In certain embodiments, support pieces 1102, 1106, 1110 are formed of more than one material, for example, two or more materials, such as two foam materials, having different densities, with the less dense material covering the denser material. In this embodiment, the less dense material is laid on the denser material at the respective base surface and the respective support plane of the support piece to allow sleep surface 1114 to function properly, whether with a right side slope or a left side slope. With the denser material sandwiched between the less dense material, the user will be positioned on the less dense material in either the first or the second orientation.

**[00143]** In this embodiment, support system 1100 allows the user to sleep on either his/her right side or left side, based on the user's sleeping preference. This sleeping preference may not be static. For example, if the user has an injury, an ache, or a desire to change his/her sleeping preference, the orientation of sleep surface 1114 can be changed at any time to accommodate the user's sleeping preference. The orientation can be changed from day to day or during the night. Moreover, from a manufacturing standpoint, a versatile support system 1100 prevents having to manufacture and distribute a sleep surface 1114 having a right side slope and a separate sleep surface 1114 having a left side slope, which would increase production and distribution costs. Finally, a potential purchaser would not have to commit to a sleep side before purchasing the product, which might be a deterrent to purchasing the product.

**[00144]** In one embodiment, support system 1100 includes one or more spacers 1152 that allow a length of support system 1100 to be adjusted and customized to a height of the user supported by support system 1100. For example, the length of sleep surface 1114 can be adjusted by adding one or more suitable spacers 1152 or replacing one or more support pieces 1102, 1106, 1110 with a suitable spacer 1152 of a different length, so that transitional lines between lateral angles of support planes defined by adjacent support pieces 1102, 1106, 1110 will desirably occur at a neck region and a hip region of the user. In one embodiment, spacer 1152 has a same or similar lateral rotational angle and/or a same or similar longitudinal rotational angle as the respective lateral rotational angle and the respective longitudinal rotational angle of an adjacent support piece or the support piece that spacer 1152 replaces. In an alternative embodiment, spacer 1152 has a different lateral rotational angle and/or a different longitudinal rotational angle as the respective lateral rotational angle and the respective longitudinal rotational angle of an adjacent support piece or the support piece that spacer 1152 replaces. As shown in FIGS. 21 and 22, spacer 1152 is positioned between first support piece 1102 and second support piece 1106 to adjust the length of sleep surface 1114. As shown in FIGS. 23 and 24, first support piece 1102 is replaced with spacer 1152 to adjust the length of sleep surface 1114.

**[00145]** Assuming the user positions his/her neck at the appropriate location on sleep surface 1114, and an overall length of sleep surface 1114 is adjustable, in one embodiment only second support piece 1106 of support system 1100 has an adjustable length. In alternative embodiments having a support system 1100 with a fixed length, both first support piece 1102 and second support piece 1106 have adjustable lengths. In this embodiment, a length of first support piece 1102 increases as a length of second support piece 1106 decreases and, conversely, the length of first support piece 1102 decreases as the length of second support piece 1106 increases.

**[00146]** In one embodiment, adjacent support pieces 1102, 1106, 1110 and spacers 1152 can be coupled together using a suitable coupling mechanism including, without limitation, one or more of the following: snaps, straps, buttons, and hook-and-loop fasteners. In certain embodiments, the length of sleep surface 1114 is adjustable by any combination of inserting one or more spacers 1152, replacing one or more support pieces 1102, 1106, 1110 with a longer or shorter spacer 1152, cutting or trimming one or more support pieces 1102, 1106, 1110 to a desired length, and removing one or more support pieces 1102, 1106, 1110. In alternative embodiments, the length of sleep surface 1114 is not adjustable but one or more of a leg region,

a torso region, and a head region of sleep surface 1114 is adjustable by any combination of inserting one or more spacers 1152, replacing one or more support pieces 1102, 1106, 1100 with a longer or shorter spacer 1152, cutting or trimming one or more support pieces 1102, 1106, 1110 to a desired length, and removing one or more support pieces 1102, 1106, 1110 without adjusting the length of sleep surface 1114.

**[00147]** In a further alternative embodiment, each support piece 1102, 1106, 1110 includes one or more inflatable fluid bladders configured to contain a fluid, such as air. In this embodiment, a length of each support piece 1102, 1106, 1110 is adjustable by adding fluid or removing fluid from one or more respective fluid bladders. By adding fluid to one or more of the respective fluid bladders, the length of the respective support piece 1102, 1106, 1110 is increased and the length of the respective support plane 1104, 1108, 1112 is also increased. Conversely, removing fluid from one or more of the respective fluid bladders, the length of the respective support piece 1102, 1106, 1110 is decreased and the length of the respective support plane 1104, 1108, 1112 is also decreased. The amount of fluid within the respective fluid bladders can be monitored and controlled electronically or by the user or caregiver using a suitable device including, without limitation, a suitable pneumatic pump or nozzle. In certain embodiments, a coupler, such as one or more snaps or straps, are utilized to maintain the desired amount of fluid within the respective fluid bladders and provide additional support to the respective support plane(s), for example, when the fluid bladders are not inflated.

**[00148]** As described herein, sleep surface 1114 is customizable to anthropometric dimensions of the individual user to facilitate support system 1100 performance that optimizes or matches the design intent - the body position of the user will prevent or limit undesirable sleep apnea episodes and provide improved comfort.

**[00149]** In certain embodiments, support system 1100 includes a plurality of support pieces, such as two support pieces, three support pieces, or more than 3 support pieces, and more specifically, at least 6 support pieces, and even more specifically, 8-20 support pieces. For example, referring to FIG. 25, in one embodiment each of a leg region 1160 corresponding to first support piece 1102, a torso region 1162 corresponding to second support piece 1106, and a head region 1164 corresponding to third support piece 1110 of support system 1100 includes a plurality of independent support wedges forming a finer gradation in the longitudinal slope of sleep surface 1114 to increase user compliance and the effectiveness of support system 1100 in preventing or limiting sleep apnea episodes and providing more comfort for the user supported on sleep surface 1114. The support wedges may be formed of one or more suitable materials

including, without limitation, a formable material, a semi-rigid material, a foam material or one or more fluid bladders.

**[00150]** In the embodiment shown in FIG. 25, first support piece 1102 includes two independent support wedges defining respective support planes positioned at different lateral rotational angles, second support piece 1106 includes three independent support wedges defining respective support planes positioned at different lateral rotational angles, and third support piece 1110 includes four independent support wedges defining respective support planes positioned at different lateral rotational angles. In alternative embodiments, each support piece 1102, 1106, 1110 includes any suitable number of independent support wedges. Generally, an increasing number of independent support wedges within a selected support piece allows for more detailed and specific contouring of sleep surface 1114 and more gradual changes in rotational angles of adjacent support wedges and support pieces along the length of sleep surface 1114.

**[00151]** For example, a support system including a series of support wedges may twist or urge the user's body to rotate and tilt the user's head in a more gradual trend than a support system including only three larger support pieces with respective support planes of different lateral rotational angles. The additional support wedges allow for more comfortable transitions between and within the lower body, the torso, and the upper body of the patient. The increased number of support wedges allow for more specific positioning of the patient's body, and a more effective therapy.

**[00152]** Referring to FIGS. 26 and 27, in one embodiment, each support piece 1102, 1106, 1110 defines a support plane positioned at the same or similar lateral rotational angle; however, each support piece 1102, 1106, 1110 is made of a material having a different density than the material used to make the other support pieces. The base material of each support piece 1102, 1106, 1110 may be the same or different than the base material of the other support pieces, but with a different density. In a particular embodiment, support system 1100 utilizes varied foam density to achieve a variation in the lateral rotation of the user's body across different body segments. In one particular embodiment, support piece 1102 is composed of the least dense material, support piece 1106 is composed of the medium density material, and support piece 1110 is composed of the most dense material.

**[00153]** In this embodiment, sleep surface 1114 is formed of support pieces cut to form support planes at the same lateral rotational angle but with different densities. To achieve a greater relative rotation at the head portion of the user, third support piece 1110 is denser than

second support piece 1106, while first support piece is less dense than second support piece 1106 and third support piece 1110 to achieve a lesser or limited relative rotation at the leg region of the user. In a particular embodiment, rather than having a plurality of discrete support pieces, sleep surface 1114 is one continuous support piece exhibiting a gradual density transition along a longitudinal length of sleep surface 1114 such that the leg portion of sleep surface 1114 is less dense than the opposite head portion of the sleep surface 1114. This feature may result in a support system that appears less intimidating to the user and more aesthetically pleasing. Moreover, sleep surface 1114 is rotatable about longitudinal axis 1115, shown in FIG. 26, so that sleep surface 1114 is oriented in one of a lateral right side slope or a lateral left side slope shown in FIG. 27.

**[00154]** Referring to FIGS. 28-35, in an alternative embodiment, sleep surface 1114 is formed of a closed air system 1160 that induces the user's body to rotate laterally when sleeping to facilitate preventing or limiting the incidence of sleep apnea. In certain embodiments, closed air system 1160 does not require electrical power or control, and allows the user to quietly move sleep orientations between the lateral left side slope and the lateral right side slope during sleep.

**[00155]** In one embodiment, closed air system 1160 includes one or more pairs of fluid bladders communicatively coupled to each other. For example, as shown in FIGS. 28 and 30, a first pair of fluid bladders 1162 is positioned within the leg region 1164 of closed air system 1160, a second pair of fluid bladders 1166 is positioned within a torso region 1168 of closed air system 1160, and a third pair of fluid bladders 1170 is positioned within a head region 1172 of closed air system 1160. In a particular embodiment, a sleep sensor is positioned in a pillow or on the bladder 1166. In a particular embodiment, the fluid bladders are plumbed together using a suitably sized tube or hose, shown schematically by reference number 1174 in FIGS. 28 and 30, or any suitable coupling mechanism providing communication between the interior cavities of the fluid bladders to allow fluid to move at a desired rate between the coupled bladders. Fluid, such as air, can be added manually or using a suitable pump to each pair of fluid bladders, for example, through one or more nozzles to adjust the firmness and lateral rotational angle of the respective pair of fluid bladders. In this embodiment, the user can adjust the side upon which he/she sleeps (even during sleep) and an amount of fluid contained within the fluid bladders to adjust the firmness of sleep surface 1114 and/or the lateral rotational angle of each support plane forming sleep surface 1114. In this embodiment, each pair of fluid bladders is

separated along longitudinal axis 1115 of support system 1100. In a particular embodiment, fluid can be added to the bladders 1166 based on the sleep state of the person.

**[00156]** In a particular embodiment, closed air system 1160 includes one or more bolsters 1176, as shown in FIGS. 29-31, positioned along at least a portion of the opposing lateral sides of support system 1100 to prevent or limit lateral migration of the user during sleep. In one embodiment, bolsters 1176 are the same or similar to bolster 1142 described above with reference to FIG. 15. Referring further to FIG. 29, each air bladder rests on and is supported by a suitable bottom layer, such as a foam material layer 1178 and/or a mattress, and can also be covered by another suitable top layer, such as a foam material layer 1180. Materials other than foam materials known to those having ordinary skill in the art can be utilized to form the bottom layer and/or the top layer. In a certain embodiment, material layer 1180 at least partially encloses or envelops one or more of the fluid bladders to retain the fluid bladders properly positioned within support system 1100. One or more of the fluid bladders in one or more of the pairs of fluid bladders are inflatable to rotate the user onto his/her right side or left side based at least in part on his/her sleep state.

**[00157]** In one embodiment, one or more pairs of fluid bladders 1162, 1166, 1170 include two wedge-shaped fluid bladders that are removably coupled to material layer 1178 and/or material layer 1180 using a suitable coupler, such as a hook and loop fastener system. For example, third pair of fluid bladders 1170 are positioned with respect to the user's upper body or head region and are removably coupled to material layer 1180 using a hook and loop fastener system such that sleep surface 1114 is adjustable based at least in part on the size and weight of the user. These fluid bladders are inflatable based on the user's sleep state to urge the upper body of the user to rotate. Additionally, first pair of fluid bladders 1162 and/or second pair of fluid bladders 1166 are also inflatable to urge the user's legs and/or the user's torso, respectively, to rotate.

**[00158]** Referring further to FIGS. 32-35, each fluid bladder of each pair of fluid bladders 1162, 1166, 1170 is inflatable to form a support piece having a desired or selected shape. Select fluid bladders may remain substantially deflated, as shown in FIG. 32, or both fluid bladders or only one fluid bladder of one or more pairs of fluid bladders may be inflated to form a desired sleep surface 1114, as shown in FIGS. 33 and 34 respectively. In an alternative embodiment, as shown in FIG. 35 a single fluid bladder 1182 may be utilized in one or more of leg region 1164, torso region 1168, and head region 1172 of closed air system 1160 positioned along longitudinal axis 1115 of support system 1100 that, when inflated, urges the user to roll

towards either the lateral right side or the lateral left side after the user is in a predetermined sleep state. In this embodiment, fluid bladder 1182 can be deflated occasionally to allow the user to reposition himself/herself. A pillow can be positioned on third pair of fluid bladders, for example, such that the pillow is inclined when one or more of the fluid bladders are inflated.

**[00159]** The fluid bladders are inflatable with air or another suitable fluid (which can be drained as desired from within the cavities of the fluid bladders into a reservoir). A fluid supply 1188, shown in FIG. 30, is positioned at or near support system 1100, such as on the floor, beneath the bed, or coupled to the bed. The fluid supply is in independent fluid communication with each pair of fluid bladders 1162, 1166, 1170 to supply a desired amount of fluid to each fluid bladder based on a signal from a control, for example.

**[00160]** In one embodiment as shown in FIG. 30, support system 1100 includes a suitable computer-implemented control system 1190 operatively coupled to closed air system 1160, such as in operational control communication with closed air system 1160. The computer-implemented control system includes a computer 1192 having one or more processors 1194 and one or more sleep sensors 1196, such as one or more pressure sensors, coupled in signal communication with processors 1194. Sleep sensors 1196 are configured to monitor the user's sleep patterns and transmit signals indicative of the sensed sleep patterns to processors 1194 for manipulation and evaluation of the data. Based at least in part on the one or more signals received from one or more sleep sensors 1196, control system 1190 is configured to inflate or deflate select fluid bladders to reposition the user during sleep to prevent or limit the occurrence of a sleep apnea episode, for example.

**[00161]** Additionally, in certain embodiments, closed air system 1160 is configured to rest on a conventional mattress or may be configured or reinforced to rest directly on a support structure, such as a bed frame or a floor. With the fluid substantially removed from each of the fluid bladders, closed air system 1160 can be folded or rolled into a compact configuration to facilitate storing and transporting closed air system 1150. In certain embodiments, closed air system is less expensive than a conventional mattress and more compact to facilitate portability of support system 1100. Additionally, closed air system 1160 as configured prevents or limits disturbance to the user's partner sleeping next to the user.

**[00162]** In certain embodiments as described herein, support system 1100 is a dynamic support system, rather than a static support system, that is configured to control the configuration of sleep surface 1114 based at least in part on data entered into control system 1190 using computer 1192, or another control operatively coupled to computer 1192, and/or

sensed by one or more sleep sensors 1196, for example, to improve the performance of sleep surface 1114 in terms of clinical efficacy and user tolerability.

**[00163]** As described herein and shown schematically, for example, in FIGS. 36 and 37, dynamic support system 1100 includes, in addition to other components, a plurality of sleep sensors 1196 configured to sense and monitor various activities including without limitation, the user's body position, a location of the user with respect to sleep surface 1114, an orientation, for example, a left side orientation or a rights side sleep orientation, of the user, the user's vital signs including his/her sleep state, and additional relevant user activity during sleep. Each sleep sensor 1196 is in signal communication with one or more processors 1194 contained within computer 1192 and configured to gather relevant data and generate and transmit to processors 1194 signals indicative of the data gathered. Sleep sensors 1196 are also configured to receive operation control signals from processors 1194.

**[00164]** Within computer 1192, data received from sleep sensors 1196 is analyzed and operational control signals are transmitted to sleep sensors 1196 as well as to other components of support system 1100, such as to fluid supply 1188 to activate fluid supply 1188 to provide air to one or more fluid bladders and/or remove air from one or more fluid bladders to adjust sleep surface 1114 based on signals generated by sleep sensors 1196 and analyzed within computer 1192. In one embodiment, computer 1192 includes suitable memory 1198 to store data sensed and/or generated by control system 1190.

**[00165]** An exemplary method 1200 utilizing control system 1190 for monitoring the sleep activities of a user positioned on support system 1100 is illustrated in FIG. 37. As described above, control system 1190 includes one or more processors 1194 configured to perform the steps as described herein.

**[00166]** Control system 1190 is activated 1202 either manually or automatically to monitor the user's sleep activities and patterns as user begins to sleep. In one embodiment, control system 1190 detects when the user begins to fall asleep 1204 and activates support system 1100 (or a dynamic sleep surface) on a delay 1206 to rotate the user at a suitable time after sleep is detected, such as after the user has been asleep for 30 minutes. In an alternative embodiment, control system 1190 is programmed to activate support system 1100 at a preset time, for example, at a 30 minute delay, without relying on monitoring the user's sleep activity. In a particular embodiment, control system 1190 delays inter-sleep rotation of the user until the user is in a deep sleep. Further, when control system 1190 detects that the user is waking, control system 1190 will activate support system 1100 to move sleep surface 1114 to an initial

configuration such that the user can exit from support system 1100. In a further embodiment, control system 1190 prevents activation of support system 1100 if control system 1190 detects the user is sleeping in a lateral decubitus position.

[00167] Prior to sleep, the user is able to input 1208 to control system 1190 sleep data 1210 including without limitation, preferred sleeping sides and positions, the user's measurements including, for example, the user's height, weight, and inseam and torso measurements, preferred lateral rotational angles and/or longitudinal rotational angles of one or more support planes defining sleep surface 1114. Based at least in part on the user's input data, control system 1190 is configured to activate support system 1100 to adjust a direction and/or a level of rotation of one or more support planes defining sleep surface 1114. For example, if the user prefers a left side slope to sleep surface 1144, control system 1114 activates fluid bladders within support system 1100 to form the desired lateral left side slope, or if the user's partner is sleeping on the left side of the user, a left angle may be created. In one embodiment, minimal adjustments are made to sleep surface 1114 to maintain the user's AHI under 5 and/or prevent snoring because apneas events and snoring may or may not be equivalent, depending on the user. Additionally, control system 1190 is configured to collect and record data obtained as the user sleeps to diagnose any undesirable or abnormal sleep activities or conditions, including the user's apnea-hypopnea index (AHI), for example.

[00168] During sleep, control system 1190 assesses the user's comfort level 1214 and, in a particular embodiment, compares the current evaluation with previous evaluations. The user's body is then mapped 1216 to map body region locations 1218, and user activities and movements 1220 during sleep. The collected data is then analyzed 1222 to determine: the location of joints including, for example, the user's neck, hips, and knees; preferred surface orientation (right side vs. left side orientation); and body orientation (e.g., mapping pressures at various locations on sleep surface 1114 as a result of the user's body orientation, for example, a lateral sleep position indicated by a narrow pressure mapping profile). In one embodiment, location of one or more support planes are calculated and located based on transition points. Under the pressure mapping, specific pressure points are identified to increase or decrease pressure. For example, select fluid bladders are inflated or deflated based on body location and desired lateral rotational angles.

[00169] Control system 1190 then assesses 1224 the user's body orientation including, for example a determination of head angle 1226 and chest angle 1228. During sleep, control systems also actively monitor 1230 the user's vital signs, which includes measuring and

monitoring the user's respiratory rate and amplitude, AHI, sleep state, snoring, and oxygen saturation ( $\text{SpO}_2$ ), for example. If an adverse event is detected, control system 1190 activates 1234 one or more components of support system 1100 to respond appropriately. For example, fluid supply 1188 may be activated to inflate or deflate one or more fluid bladders. Control system 1190 may activate fluid supply 1188 based on one or more of the following events: detection of snoring, detection of an AHI episode (apnea and/or hypopnea), and detection that the user is in a supine position (e.g., supine torso, upper respiratory tract (URT) within  $45^\circ$  of vertical). Control system 1190 may also activate support system 1100 to vibrate to wake the user should control system 1190 detect an adverse event, such as an apnea episode.

**[00170]** Referring to FIGS. 38-41, in one embodiment a sleep apnea therapy system is a design based on how an average user responds to the therapy tested on a sufficiently large population. The sleep apnea therapy system will effectively and tolerably treat any user's sleep apnea. As a result, the therapy can be modified to decrease a level of therapy (specifically, an amount of rotation) and still achieve clinical efficacy while optimizing user comfort and increasing usage compliance. By learning how the user reacts to variations in therapy, the sleep apnea therapy system is adjustable to optimize the results of therapy. As shown in FIGS. 38-41, the sleep apnea therapy system is design to include, in the embodiment illustrated, an active control of surface (e.g., rotation planes, rotation angles, rotation time/duration, fluid bladder pressure); capabilities to sense and assess tolerability (e.g., sleep state/stage, vitals, movement, user assessment); and sense and assess clinical efficacy (e.g., AHI, respiratory rate, head orientation). With these assessments, tolerability and user compliance is maximized for a clinically effective treatment of obstructive sleep apnea.

**[00171]** As shown in FIG. 38, the sleep apnea therapy system incorporates sensing of key elements and evaluates connections between those elements until the balance between the elements is optimized, as shown in FIGS. 39 and 40. As a result, the system is capable of maintaining balance between efficacy and tolerability in spite of changes over time (e.g., the user has a cold or develops a higher body mass index (BMI) illustrated in FIG. 41).

**[00172]** In one embodiment, apnea therapy can be integrated as an option in a continuous lateral rotation therapy (CLRT) system. An exemplary CLRT system is configured to deliver lateral rotation as a therapy for the prevention of pressure ulcers, as well as for use in the prevention of ventilator-associated pneumonia and muscular wasting associated with prolonged immobility. The exemplary CLRT system is suitable for use as a therapy for the prevention of sleep apnea with the addition of the following components or elements. In one embodiment, the

CLRT system includes a restrained lateral rotation to create or develop progressively greater rotation by limiting rotation in a torso region and/or a head region of the user. Additionally, an augmented lateral rotation increases rotation in the torso region and/or the head region of the user.

**[00173]** Referring to FIGS. 42-46, an exemplary CLRT system 1300 includes a control system 1302 configured with a rotation function (augmented or restrained rotation). Referring to FIG. 42, control system 1302 is operatively coupled to a support system 1304. Control system 1302 includes an apnea setting configured to select a number of support planes, dimensions of each support plane, and a desired lateral rotational angle and/or a desired longitudinal rotational angle at which one or more support planes are positioned to define the sleep surface. Further, control system 302 includes a rotation function that allows constrained rotation at a torso region and/or a head region of the sleep surface (e.g., by pressure modification or by physical constraint), as well as supplemented rotation via a cushion.

**[00174]** As show in FIG. 43, control system 1302 includes an apnea mode, wherein blowers are controlled to initiate and maintain rotation of the support planes. Within the apnea mode, control system 1302 allows the user or a caregiver to select and/or define one or more therapy modes (e.g., an amount and/or a location of rotation). In one embodiment, control system 1302 is configured or programmed to suggest rotation protocol based on sensed or input data including, without limitation, one or more of the following: AHI score, BMI, sensed respiratory rate, and sensed SpO<sub>2</sub> history. Control system 1302 is also configured or programmed to select a left side slope or a right side slope based on user preference or an alternating lateral rotation, select a reverse trend or composite longitudinal angle, and manually cancel a protocol and/or return the sleep surface immediately to a flat, initial position. Alternating lateral rotation can be specified to alternate after an elapsed time period, to rotate at a certain speed to avoid waking the user, and to gradually increase lateral rotational angles from a low initial lateral rotational angle at a first rotation toward the maximum desired lateral rotational angle after a specified number of rotations.

**[00175]** In one embodiment, support system 1304 includes a base support 1306 including a plurality of inflatable fluid bladders aligned generally parallel to a longitudinal axis of support system 1304 forming a single support plane 1308 having a lateral rotation angle  $\theta$  of 5° to 15°, or more specifically, 10°, with respect to a base plane 1310 of base support 1306. One or more supplemental support wedges 1312 are positioned on support plane 1308 within one or more of the leg region, the torso region, and the head region of support system 1304. In this

embodiment, supplemental support wedge 1312 is a wedge-shaped inflatable fluid bladder. As shown in FIG. 44, supplemental support wedge 1312 is positioned at the head region of support system 1304 and forms a supplemental support plane 1314 having a lateral rotation angle  $\gamma$  of  $5^\circ$  to  $15^\circ$ , or more specifically,  $10^\circ$ , with respect to a base plane 1316 of supplemental support wedge 1312. As a result, in the embodiment shown in FIG. 44 a supplemental support plane 1314 is positioned at a total lateral rotational angle  $\iota$  of  $20^\circ$  with respect to base plane 1310 of base support 1306 (the sum of angle  $\theta$  and angle  $\gamma$ ). In alternative embodiments, the total lateral rotational angle may be any suitable angle, less than  $20^\circ$  or greater than  $20^\circ$ . Further, one or more supplemental support wedges 1312 can be positioned within one or more of the leg region, the torso region, and the head region of support system 1304.

[00176] Referring to FIGS. 45 and 46, in one embodiment support system 1304 includes laterally positioned side constraints 1320 to limit inflation of individual fluid bladders forming base support 1306. Support system 1304 may include, with or without laterally positioned side constraints 1320, a plurality of fixed length bands 1322 positioned with respect to individual fluid bladders, such as between adjacent fluid bladders, to limit inflation of the individual fluid bladders.

[00177] In one embodiment, a posture garment or shirt 1500 is worn by a user suffering from sleep apnea to apply an appropriate force, such as a tugging force, on the shoulders, arms, and/or head of the user to urge or cause the desired or necessary head turn to open up the user's upper respiratory tract to prevent or limit the occurrence of sleep apnea or in the event of a sleep apnea episode. Applying forces to cause the user to turn his/her entire body to the lateral decubitus position is an alternative approach to achieving this desired head angle; this may involve the use of whole-body garments or a pant garment in combination with a shirt garment.

[00178] As shown in FIGS. 47 and 48, posture shirt 1500 includes one or more areas 1502 located on a front portion of posture shirt 1500, as shown in FIG. 47, and/or a back portion of posture shirt 1500, as shown in FIG. 48, including a material panel and/or material weaves having a different elasticity than other areas of posture shirt 1500. Because of the different material elasticity within areas 1502, areas 1502 tend to pull or urge select parts of the user's torso, extremities, head, and/or neck in a desired direction to open the upper respiratory airway. In a particular embodiment, sections or panels of posture shirt 1500 within areas 1502 are made of a different elastic material that work cooperatively to properly position the user's body. Posture shirt 1500 may have long sleeves, short sleeves, or may not include sleeves, and/or have a hood. Any suitable material known to those having ordinary skill in the art may

be used within areas 1502 and include, without limitation, elastic materials based on composition (one or more of nylon, polyester, polyester fleece, and/or cotton) or weave (one or more of plain, basket, and twill weaves) that impart preferential deformability and recovery inducing a change in the user's posture.

**[00179]** In one embodiment, a compression posture shirt 1500 is worn like a typical shirt and naturally twists the torso, neck and/or head of the user. Unlike conventional posture shirts, there is no need to insert bladders or tennis ball-like inserts to urge the user to turn or rotate from a supine sleep position. Moreover, compression posture shirt 1500 for sleep apnea does not require any user training because posture shirt 1500 pulls and tugs on the user without the need of intervention from the user.

**[00180]** In certain embodiments, electrical circuitry, such as one or more processors and/or one or more circuit boards, is operatively coupled to, such as in electrical or electronic communication with, control system 1190 to monitor operation of one or more components of support system 1100 or control system 1302 to monitor operation of one or more components of support system 1304, collect, process, and/or store information, such as operation data and motor usage data, and transmit information, such as operation data and motor usage data, to one or more of the following computer-implemented machines or devices including, without limitation, a control and/or display device within or operatively coupled to support system 1100 or support system 1304, and/or a control and/or display device on a computer or network of computers at one or more nurse stations or administrative stations, for example.

**[00181]** In one embodiment, electrical circuitry, such as one or more processors and/or one or more circuit boards, is contained within control system 1190 or control system 1302 and connected in communication with support system 1100 or support system 1304, respectively. In a particular embodiment, one or more sensors or other suitable detection components are operatively coupled to support system 1100 or support system 1304 and/or control system 1190 or control system 1302 to detect operation. The one or more sensors are configured to generate and transmit electronic signals representative of the detected operation to the circuit board, which is configured to collect, process, and/or store such information, and generate and transmit information to one or more computer-implemented machines or devices in communication with the circuit board, as described above.

**[00182]** In certain embodiments, the one or more computer-implemented machines or devices in communication with the circuit board include a controller in signal communication, either wired or wireless signal communication, with the circuit board contained within support

system 1100 or support system 1304. The controller includes a suitable display to display information received from the circuit board and/or information generated by the controller based on the information received from the circuit board. In a particular embodiment, the controller is configured to generate command signals and transmit the command signals to the circuit board contained within support system 1100 or support system 1304 to control operation of support system 1100 or support system 1304 and/or adjust parameters and/or limits, for example, programmed into the circuit board.

**[00183]** [95] In one embodiment, a chest constriction device 400 assists in expiring air from the user's lungs. Referring to FIGS. 49-52, a belt 402 or strap made of a suitable material, such as nylon, is placed generally around the circumference of the user at the thorax or chest region of the user and coupled using a suitable fastener, such as a buckle 404, to retain belt 402 properly positioned about the user. Any suitable material known to those having ordinary skill in the art that is comfortable to the user and provides the required strength and flexibility may be used to make belt 402. A constrictor device 406 is operatively coupled to belt 402. Constrictor device 406 is movable between an initial or relaxed position, as shown in FIG. 39, and an activated or constricted position, as shown in FIG. 49. More specifically, referring to FIGS. 49-52, constructor device 406 is configured to selectively shorten a length of belt 402, thereby applying a compressive force on the thorax of the user.

**[00184]** [96] In one embodiment, one or more physiological sensors 408 are coupled to or integrated in belt 402 and configured to detect the user's sleep state. Physiological sensor 408 may include one or more of the following sensors: a position sensor, a pressure sensor, a temperature sensor, an acoustic sensor, a moisture sensor, an RFID tag, an accelerometer, a proximity sensor, a level sensor, or another physical tracking sensor in signal communication with a processor 410 positioned within or operatively coupled to constriction device 406 and configured to provide an input signal to processor 410. Upon receiving an input signal from physiological sensor 408, processor 410 is configured to activate an actuator 412 in signal communication with processor 410 to rotate a lever 414 against a spring 416. As lever 414 rotates, a length of belt 402 shortens to apply pressure against the thorax region of the user. Lever 414 is rotatable against spring 416 in an opposite rotational direction to increase the length of belt 402 and release pressure against the thorax region of the user. Constrictor device 406 is programmed to perform a regime of constrictions and relaxations to mitigate sleep apnea.

**[00185]** [97] In one embodiment, constrictor device 406 may also be used as a continuous positive airway pressure (CPAP) device and therapy may be activated by a caregiver

or the user. Although not shown, the data may be communicated to an electronic medical records (EMR) system, and the caregiver and the user may be provided with a graphical user interface (GUI) to control chest constriction device 400.

**[00108]** Referring now to FIGS. 53-94, various illustrative embodiments of a person support apparatus configurable to assume a “progressive” lateral tilt position are shown. The person support apparatus may have any of the features described in this document, or any combination of such features and/or other features. The person support apparatus or portions thereof may be embodied as a mattress, a mattress overlay or topper, a cover for a mattress, a cushion or a pad, for example. In a progressive lateral tilt position, the person support apparatus assumes a ramp-like configuration intended to tilt a person’s body laterally, to one side, such that different portions of the person’s body are tilted laterally in the same general direction (e.g., all tilted to the same side), but at different lateral angles. As used herein, “lateral tilt,” “lateral angle,” or “tilt” may be used to refer to, among other things, an angle of a surface of the person support apparatus relative to the horizontal and with reference to (e.g., defined by rotation about) a longitudinal axis of the person support apparatus. In some cases, the different lateral tilt angles are defined so that the maximum lateral tilt angle of a portion of the person support apparatus supporting the person’s head is greater than the maximum lateral tilt angles of portions of the person support apparatus supporting other portions of the person’s body. An example of the general construction of such an apparatus is shown in FIGS. 53-54, and exemplary embodiments are shown in FIGS. 55-94. In FIG. 53, a person support apparatus 5300 includes a number of support sections 5316, 5318, 5320 enclosed in an interior region defined by a cover 5314. Although only three support sections 5316, 5318, and 5320 are shown, it should be understood that the person support apparatus 5300 may contain any number of such sections, depending on the requirements of a particular design or for other reasons.

**[00109]** The support sections 5316, 5318, 5320 are positioned along a length  $l$  of the person support apparatus 5300, with the support section 5316 positioned adjacent a head end 5310 of the person support apparatus 5300, the support section 5320 positioned adjacent a foot end 5312 of the person support apparatus 5300, and the support section 5318 positioned between the support sections 5316, 5320. Each of the support sections 5316, 5318, 5320 has a support surface 5422 (FIG. 54), which is configured to bear a load, e.g., to support at least a body portion of a person on the person support apparatus 5300. Portions of the support surface 5422 may be rigid, semi-rigid, or non-rigid, depending on the requirements (e.g., patient comfort, stability, etc.) of a particular design and/or configuration of the person support

apparatus 5300. Illustratively, the support section 5316 is configured to support a person's head and/or neck region, the support section 5318 is configured to support a person's torso, hip, and/or thigh region, and the support section 5320 is configured to support a person's legs and/or feet. In embodiments having a greater number of support sections, each support section may be configured to support a correspondingly smaller portion of the person's body, and vice versa.

[00110] As explained in more detail below with respect to the embodiments of FIGS. 55-94, each of the support sections 5316, 5318, 5320 includes an inflatable portion which, alone or in combination with one or more other support portions (e.g., non-inflatable support portions, such as foam pieces or three-dimensional fiber network layers), can cause the support surface 5422 to assume a progressively greater maximum lateral tilt angle along the length *l* from the foot end 5312 to the head end 5310, or vice versa, in order to provide a therapeutic effect to a person positioned on the person support apparatus 5300 or for other reasons. As used herein, "progressive lateral tilt angle" may refer to, among other things, a maximum lateral tilt angle that begins with a relatively small tilt angle in the foot section 5320 (e.g., in the range of about 0 to about 10 degrees), increases to a larger maximum tilt angle in the seat section 5318 (e.g., in the range of about 10 to about 20 degrees) and increases to still a larger maximum tilt angle in the head section 5316 (e.g., in the range of about 15 to about 35 degrees). As used herein, "maximum" may be used to, among other things, convey the idea that each support section 5316, 5318, 5320 may be configurable to assume smaller tilt angles or the same tilt angle from time to time, but that the largest tilt angle achievable by each of the support sections 5316, 5318, 5320 is different.

[00111] The support sections 5316, 5318, 5320 are also each configurable to assume a substantially flat position, e.g., to provide a more typical flat or horizontal rest surface during periods in which the progressive lateral tilt angle is not required or desired. As such, the person support apparatus 5300 is selectively configurable by, for example, an air control system 5328, to assume a progressive lateral tilt position and at least one other position (e.g., the flat position). The air control system 5328 can selectively inflate and deflate the inflatable portions of the support sections 5316, 5318, 5320 to achieve a desired or required (e.g., flat or tilt) configuration of the person support apparatus 5300, and can adjust such position dynamically in response to various inputs as described in this document.

[00112] In the simplified view of FIG. 53, each of the connections 5322, 5324, 5326 represents a number of different types of couplings including air conduits (e.g., plastic tubing) and electronic signal paths (e.g., insulated wiring and/or wireless connections), in order

to electronically and pneumatically couple the air control system 5326 to the each of the support sections 5316, 5318, 5320, respectively. For example, one or more sensors (e.g., pressure sensors, force sensors, and/or angle sensors) may be coupled to each of the support sections 5316, 5318, 5320, and some of the connections 5322, 5324, 5326 may electronically communicate data obtained from the sensors to the air control system 5326. The sensor data may indicate, for example, the air pressure inside the inflatable portions and/or the current lateral tilt angle of the support surface 5422. Although not specifically shown in FIG. 53, it should be understood that the air control system 5328 may be communicatively coupled to other devices, e.g., via a direct wired or wireless connection or by an electronic communication network. For example, the air control system 5328 may communicate air pressure data and/or lateral tilt angle data for the various support sections 5316, 5318, 5320 over a network to a healthcare communication system, such as a facility's nurse call system, an electronic medical records system, and/or other devices and systems. Such a network may be embodied as, for example, a healthcare facility's internal network, a "private cloud," a secure portion of the Internet, and/or others, and may enable longer range communications (e.g., via ETHERNET) and/or shorter range communications (e.g., via WIFI, BLUETOOTH, WLAN, or Near Field Communication (NFC)).

**[00113]** Referring to FIG. 54, an exemplary sectional view of the support section 5316 is shown. It should be understood that each of the other support sections 5318, 5320, may have the same or a similar composition as the support section 5316, although not specifically shown. Illustratively, the support section 5316 includes a number of support portions or pieces including an upper layer 5412, a middle layer 5414 (which includes illustrative support portions 5414A and 5414B), a lower layer 5416, a side member 5418, and a side member 5420. The support portions 5412, 5414, 5416, 5418, 5420 are located in the interior region defined by the cover 5314. In some embodiments, the cover 5314 may be omitted or may enclose less than all of the support sections 5316, 5318, 5320 and/or the support portions 5412, 5414, 5416, 5418, 5420. Further, some embodiments of the person support apparatus 5300 may not include all of the support sections 5316, 5318, 5320 and/or the support portions 5412, 5414, 5416, 5418, 5420. For example, one or more of the support portions 5412, 5416, 5418, and/or 5420 may be omitted from the support section 5316 and/or the support sections 5318, 5320.

**[00114]** The support section 5316 has a width  $w$ , which in some embodiments is sized to substantially coincide with a width of an underlying mattress or other support structure (e.g., a frame or a deck section of a bed). The side members 5418, 5420 are each positioned adjacent

to a side 5424, 5426 of the support section 5316, respectively. The support portions 5412, 5414, 5416 are positioned between the side members 5418. At least one of the upper layer 5412, the middle layer 5414, and the lower layer 5416 includes one or more inflatable portions as described herein. In some embodiments, the upper layer 5412 may include a non-inflatable material, such as foam and/or a three-dimensional woven or nonwoven fiber network or other material (e.g., SPACENET or TYTEX). In some embodiments, the lower layer 5416 may include a non-inflatable material, such as a molded foam base. Illustratively, the middle portions 5414A, 5414B alone or in combination with the upper layer 5412 and the lower layer 5410 are each configured to provide the desired lateral tilt angle of the support surface 5422. In some embodiments, each of other portions 5414A and 5414B include one or more inflatable bladders that can be selectively inflated and deflated to provide a desired lateral tilt position or a flat position of the support surface 5422. For example, the portion 5414B may be embodied as a wedge-shaped inflatable (e.g., one or more air bladders) or non-inflatable (e.g., foam) piece that is configurable to provide a lateral tilt angle A, to tilt the person situated on the person support apparatus 5300 in the direction of the side 5424, when the middle portion 5414A is either absent or deflated and the portion 5414B is present and/or inflated. Similarly, the portion 5414A may be embodied as a wedge-shaped inflatable or non-inflatable piece that is configurable to provide a lateral tilt angle B to tilt the person situated on the person support apparatus 5300 in the direction of the side 5426 when the middle portion 5414B is either absent or deflated and the portion 5414A is present and/or inflated.

**[00115]** Referring now to FIGS. 55-56, an illustrative embodiment 5500 of a support portion, which may be used as a middle portion 5414A and/or a middle portion 5414B of a support section 5316, 5318, 5320, for example, is shown. The support portion 5500 is embodied as a bellows-style bladder having a substantially triangular cross section 56-56 when inflated (FIG. 56). The support portion 5500 includes a lower surface 5510 and an upper surface 5512, each of which are defined by a pair of laterally spaced sides (side 5514 and side 5516 of the upper surface 5512; side 5514 and side 5518 of the lower surface 5510) and longitudinally spaced ends (end 5520 and end 5522 of the upper surface 5512; end 5524 and opposite end, obscured in FIG. 55, of the lower surface 5510). The upper surface 5512 and the lower surface 5510 are joined together (e.g., by radio frequency (RF) welding, adhesive, or other suitable technique) along the side 5514 to form a hinge 5522. A bellows bladder 5526 is coupled to and extends between the upper surface 5512 and the lower surface 5510 such that when inflated, the upper surface 5512 is rotated about an axis 5554, which extends along the

hinge 5552. The upper surface 5512 can thereby be tilted at a desired lateral tilt angle relative to the lower surface 5510, where the desired lateral tilt angle may differ depending on, for example, a characteristic of a person situated on the person support apparatus 5300 (e.g., the person's height, weight, and/or therapeutic needs) and/or the position of the support section 5316, 5318, 5320 in which the support portion 5500 is used relative to the person support apparatus 5300 as a whole.

[00116] The bellows bladder 5526 has a pleat 5528, which extends around the perimeter of the bladder 5526 and enables the bladder 5526 to fold in on itself when deflated. A number of baffles 5530, 5532, 5534, 5536 each having different lengths  $l1$ ,  $l2$ ,  $l3$ ,  $l4$  are positioned in an interior region defined by the bellows bladder 5526. Each of the baffles 5530, 5532, 5534, 5536 has a top end 5538, 5540, 5542, 5544, which is coupled to an underside of the upper surface 5512, and a bottom end 5546, 5548, 5550, 5552, which is coupled to an underside of the lower surface 5510. The illustrative baffles 5530, 5532, 5534, 5536 each have substantially the same width  $w1$ , although they may have different widths in other embodiments. The baffles 5530, 5532, 5534, 5536 are spaced from one another by distances  $d1$ ,  $d2$ ,  $d3$ , as shown in FIG. 56. The distances  $d1$ ,  $d2$ ,  $d3$  may be the same or different, depending on the requirements of a particular design, or for other reasons. In general, the dimensions of each of the baffles 5530, 5532, 5534, 5536 are defined to retain the support portion 5500 in a position in which the upper surface 5512 is tilted at the desired maximum lateral tilt angle. For example, if the upper surface 5512 is to be tilted at a lateral tilt angle in the range of about 20 degrees when the bellows bladder 5526 is inflated, the lengths  $l1$ ,  $l2$ ,  $l3$ ,  $l4$  and the distances  $d1$ ,  $d2$ ,  $d3$  are configured to retain the support section 5500 in the proper position to achieve such angle.

[00117] The illustrative support section 5500 is generally made of one or more cloth materials, such as nylon sheets (e.g., twill and/or taffeta). Portions of the support section 5500 that are coupled together may be coupled by any suitable fastening techniques, such as RF welding, stitching, snaps, rivets, and/or others. One or more fluid ports, e.g., a fill port 5554 and a vent port 5556, are coupled to the bellows bladder 5526 and, in use, connected to a fluid supply (e.g. a blower), which may be incorporated into or in communication with the air control system 5328.

[00118] Referring now to FIGS. 57-58, an embodiment 5700 of a person support apparatus includes a number of support sections 5712, 5714, 5716, each of which incorporates least one of the support portions 5500, is shown. The support sections 5712, 5714, 5716 are supported by a base 5710. The base 5710 may be constructed of foam and/or one or more air

belladders, for example. Each of the support sections 5712, 5714, 5716 has a bellows-type bladder that, when inflated, tilts a person situated on the person support apparatus 5700 in a direction toward a side member 5718. The side member 5718 may be constructed of foam and/or one or more air bladders, for example, and is sized to retain the person on the person support apparatus 5700 notwithstanding the lateral tilt angles provided by the support sections 5712, 5714, 5716.

[00119] The bellows bladder 5526 of each of the support sections 5712, 5714, 5716 is constructed to provide the maximum lateral tilt angle desired of the respective section 5712, 5714, 5716. To do this, the pleat 5528 or the baffles 5530, 5532, 5534, 5536 may be differently sized for each of the sections 5712, 5714, 5716 (e.g., by having different lengths). In other embodiments, the bellows bladder 5526 of each of the support sections 5712, 5714, 5716 may have the same or similar construction, and the desired maximum lateral tilt angle may be achieved by varying the amount of air pressure in the interior region of the bellows bladder 5526.

[00120] In the embodiment of FIGS. 57-58, each of the support sections 5712, 5714, 5718 has a different maximum lateral tilt angle  $x$ ,  $y$ , and  $z$ . Further, the support sections 5712, 5714, 5718 have different lengths  $l_x$ ,  $l_y$ ,  $l_z$ . In other embodiments, one or more of the support sections 5712, 5714, 5718 may have the same maximum lateral tilt angle and/or the same length.

[00121] In the person support apparatus 5700, the support section 5712 is positioned adjacent a head end 5720 of the person support apparatus 5700, the support section 5716 is positioned adjacent a foot end 5722, and the support section 5714 is positioned between the head end 5720 and the foot end 5722. Further, in the illustrative person support apparatus 5700, the maximum lateral tilt angle  $x$  is greater than the maximum lateral tilt angle  $y$ , and the maximum lateral tilt angle  $y$  is greater than the maximum lateral tilt angle 5716. In FIG. 57, the bellows bladder 5526 of each of the support sections 5712, 5714, 5716 is inflated, causing the person support apparatus 5700 to assume a progressive lateral tilt position as described herein. In FIG. 58, the bellows bladders 5526 of each of the sections 5712, 5714, 5716 are deflated, causing the person support apparatus 5700 to assume a substantially flat position. In the substantially flat position, the side member 5718 is also deflated. While only the progressive lateral tilt position and the substantially flat position are shown in the drawings, it should be understood that the bellows bladders 5526 of each of the sections 5712, 5714, 5716 and the side member 5718 can be selectively inflated (e.g., to different levels or angles), so that the person

support apparatus 5700 can assume a range of positions between the progressive lateral tilt position and the substantially flat position.

**[00122]** Referring now to FIGS. 59-60, an embodiment 5900 of a support section, which may be used as a support section 5316, 5318, 5320, for example, is shown. The support section 5900 includes a pair of complementary bellows-type bladders 5910, 5912, each of which may be embodied as the support portion 5500, described above. The bladders 5910, 5912 are supported by a lower layer 5914 and a base 5916. The lower layer 5914 may be embodied as a number of support cushions and may be similar in construction to the lower layer 5416 described above. The base 5916 may be constructed of, for example, one or more air bladders, foam, or a combination thereof. Illustratively, the base 5916 is crib or tray shaped, having side portions 5924, 5926 extending upwardly to form a substantially u-shaped cross-section. Additionally, side members 5918, 5922 are supported by or integrated with the side portions 5924, 5926. The side members 5918, 5922 may be constructed of, for example, one or more air bladders, foam, or a combination thereof. The side members 5918, 5922 are, alone or in combination with the base 5916, sized to extend upwardly above the height of the bellows bladder vertices 5930, 5932.

**[00123]** In FIG. 59, the bellows bladder 5910 is inflated and the bellows bladder 5912 is deflated, to tilt the upper surface 5512 at an angle having a vertex at 5930 (and thereby tilt a body portion of a person situated thereon toward the side member 5922). In FIG. 60, the bellows bladder 5910 is deflated and the bellows bladder 5912 is inflated, to tilt the upper surface 5512 at an angle having a vertex at 5932 (and thereby tilt a body portion of a person situated thereon toward the side member 5918).

**[00124]** Referring now to FIG. 61, a top view of an embodiment 6100 that is similar to the person support apparatus 5700 is shown. A difference between the embodiment 5700 and the embodiment 6100 is that the embodiment 6100 includes a side member 6128 that has a length  $l_s$ , which is less than the length of the person support apparatus (e.g., the length  $l$  shown in FIG. 53). The side member 6128 and each of the support sections 5712, 5714, 5716 are coupled to a base sheet by any suitable fastening technique, such as any of the techniques mentioned herein. The side member 6128 and each of the support sections 5712, 5714, 5716 are pneumatically coupled to an air system 6124 by fill lines 6110, 6114, 6118, 6122 and vent lines 6112, 6116, 6120, 6124, respectively. In general, the air system 6126 includes a processor or controller that executes control logic (which may be embodied as computer-executable instructions or routines, etc.), to operate an air supply/vacuum device (e.g., a blower,

compressor, etc.) to selectively inflate and deflate the inflatable portions of the support sections 5712, 5714, 5716 and the side member 6128. The air system 6126 or portions thereof may be embodied as the air control system 5328, described above.

**[00125]** FIGS. 62-63 illustrate additional details of the side member 6128. The illustrative side member 6128 is an elongated inflatable bladder having a length that is greater than its width. As shown in FIG. 63, the side member 6128 has perimeter welds or seams (e.g., RF welds) 6310, 6312, 6314. In the illustration, the welds 6310, 6312, 6314 are spaced substantially equidistantly from one another, however this need not be the case. The welds 6310, 6312, 6314 may be configured to provide vertical stability to the side member 6128 or for other reasons. Additionally, a tether 6316 may couple the side member 6128 to the base sheet 6130.

**[00126]** Referring now to FIG. 64, a cover 6400 for the person support apparatus 5300, or any of the embodiments thereof disclosed herein, including the embodiment 5700, is shown. In general, the cover 6400 is configured to slide over the components of the person support apparatus 5300 such that all of the components (e.g., support portions 5712, 5714, 5716 and side member 5718) are retained or enclosed in an interior region of the cover 6400. Additionally, the cover 6400 has a number of expandable portions 6416, 6418, 6420, 6422 corresponding to the support portions 5712, 5714, 5716 and the side member 5718. The expandable portions 6416, 6418, 6420, 6422 are designed to allow the cover 6400 to accommodate the support portions 5712, 5714, 5716 in the lateral tilt positions, flat positions, and positions therebetween, as well as the side member 5718 when it is inflated. Illustratively, the portions 6416, 6418, 6420, 6422 are pleated, with each of the portions 6416, 6418, 6420 having a different number of pleats as needed to accommodate the different maximum lateral tilt angles of each of the portions 5712, 5714, 5716. The expandable portions 6416, 6418, 6420, 6422 are coupled to a perimeter skirt 6410, which may be elasticized to secure the cover 6400 around the person support apparatus 5700. The expandable portions 6416, 6418, 6420, 6422 are also coupled to top surfaces 6412, 6414. The top surface 6414 is coupled to the top surface 6412 by a seam 6424, which allows the top surface 6414 to move independently of the top surface 6412. Together, the skirt 6410, the expandable portions 6416, 6418, 6420, 6422, and the top surfaces 6412, 6414 form a hollow interior region that can receive a person support apparatus such as the person support apparatus 5700. The various portions of the cover 6400 may be constructed of a nylon material, for example.

**[00127]** Referring now to FIGS. 65-66, an embodiment 6500 of a person support apparatus is shown. The person support apparatus 6500 includes a number of non-inflatable support portions 6510, 6512, 6514, a number of inflatable support portions 6516, 6518, 6520 supported by the non-inflatable support portions 6510, 6512, 6514, respectively, and a non-inflatable side member 6522. The non-inflatable support portions 6510, 6512, 6514 and the side member 6522 may be constructed of foam, for example. The inflatable support portions 6516, 6518, 6520 may include one or more air bladders, and may each be embodied as the support portion 5500, described above.

**[00128]** The illustrative non-inflatable support portions 6510, 6512, 6514 are each embodied as a substantially triangular or wedge-shaped support piece, each having a hypotenuse side 6524, 6526, 6528. The length of the side 6526 is greater than the length of the side 6528, and the length of the side 6524 is greater than the length of the side 6526, such that when the inflatable portions 6516, 6518, 6520 are deflated, the person support apparatus 6500 has progressively greater lateral tilt angles, with the lateral tilt angle increasing from the foot end 6532 to the head end 6530 of the person support apparatus 6500. When the inflatable portions 6516, 6518, 6520 are inflated, the person support apparatus 6500 assumes a substantially flat position as shown in FIG. 66. Intermediate positions are also provided. For example, one or more of the inflatable portions 6516, 6518, 6520 may be deflated while the other(s) are inflated, to allow a greater degree of variation in the elevation of the support sections, or for other reasons. The side member 6522 is positioned adjacent the vertex side of the non-inflatable support portions 6510, 6512, 6514 (opposite the hypotenuse sides 6510, 6512, 6514) and sized so that its vertical height substantially corresponds to the vertical height of the inflatable support portions 6516, 6518, 6520 when inflated. The side member 6522 may be constructed of, for example, foam.

**[00129]** Referring now to FIGS. 67-68, an embodiment 6700 of a person support apparatus includes a base 6710 and a number of support sections 6740, 6742, 6744, which generally correspond to the support sections 5316, 5318, 5320 of FIG. 53. The support sections 6740, 6742, 6744 are supported by the base 6710. Each of the support sections 6740, 6742, 6744 includes an inflatable support portion 6712, 6714, 6716, a stiffener plate 6730, 6732, 6734 supported by the inflatable support portion 6712, 6714, 6716, and a non-inflatable support portion 6718, 6720, 6722 supported by the stiffener plate 6730, 6732, 6734.

**[00130]** The base 6710 is substantially rectangular in shape and has a width that is wider than the width of the support sections 6740, 6742, 6744. A non-inflatable support member

6724 is supported by the base 6710 and positioned along an edge of the base 6710, adjacent a hinge 6746, which extends along the length of the person support apparatus 6700. An inflatable support member 6726 is supported by the non-inflatable support member 6724. The inflatable support member 6726 is sized to have a vertical height that extends upwardly above a portion of the top surface of the support sections 6740, 6742, 6744 that is adjacent to the support member 6726.

**[00131]** When inflated, the inflatable support portions 6712, 6714, 6716 cause the top surfaces of the non-inflatable support portions 6718, 6720, 6722 to assume the desired progressive lateral tilt angle as described above. When the inflatable support portions 6712, 6714, 6716 are deflated, the top surface of the non-inflatable support portions 6718, 6720, 6722 is substantially flat as shown in FIG. 68. Intermediate positions of the person support apparatus 6700, in which less than all of the inflatable support portions 6712, 6714, 6716 are inflated, are also provided, as mentioned above.

**[00132]** The stiffener plates 6730, 6732, 6734 may be constructed of, for example, a rigid or semi-rigid plastic, stainless steel, or other suitable material. The stiffener plates 6730, 6732, 6734 provide additional support for the non-inflatable portions 6718, 6720, 6722 and may thereby facilitate pivoting of the non-inflatable portions 6718, 6720, 6722 to the desired lateral tilt angle. Additionally or alternatively, the stiffener plates 6730, 6732, 6734 may provide a substrate to which one or more sensors may be mounted for the purpose of detecting and monitoring the lateral tilt angle of each of the support sections 6740, 6742, 6744. For example, an angle sensor (e.g., an inclinometer or accelerometer) may be mounted to each stiffener plate 6730, 6732, 6734 to measure the lateral tilt angle of its respective support section 6740, 6742, 6744. The angle data obtained by such sensors may be transmitted to and analyzed by a control system (e.g., by a feedback loop of the control system 5238), in order for the control system to make adjustments to the air pressure supplied to the inflatable portions 6712, 6714, 6716, as may be needed to maintain the desired lateral tilt angles for each of the sections 6740, 6742, 6744.

**[00133]** Referring now to FIGS. 69-70, an embodiment 6900 of an inflatable support section, which may be used as a middle section 5414A and/or 5414B, for example, is shown. A number of fluidly connected bladders 6912, 6914, 6916 are formed from a base sheet 6910. Each of the bladders 6912, 6914, 6916 has a vertical height  $h_1$ ,  $h_2$ ,  $h_3$ , respectively, which extends vertically upwardly from the base sheet 6910 and also equally vertically downwardly below the base sheet 6910. The vertical heights  $h_1$ ,  $h_2$ ,  $h_3$  progressively increase, such that the

height  $h_1$  is smaller than the height  $h_2$  and the height  $h_2$  is smaller than the height  $h_3$ . As such, when inflated, the bladders 6912, 6914, 6916 can provide the desired lateral tilt angle.

**[00134]** Channels 6920, 6922 fluidly couple the bladders 6912, 6914, 6916 to one another. The length of the channels 6920, 6922 generally defines the amount of space between the bladders 6912, 6914, 6916. The amount of space between the bladders 6912, 6914, 6916 may be the same or different, in accordance with the requirements of a particular design. Fluid ports 6930, 6932 couple the bladders 6912, 6914, 6916 to an air supply (e.g., via plastic tubing). The ports 6930, 6932 may each include a valve, which may be selectively opened and closed (e.g., by the control system 5328) to retain air in or vent air from the bladders 6912, 6914, 6916 as needed. While the support section 6900 is illustrated with three inflatable bladders 6912, 6914, 6916, it should be understood that any number of bladders may be used. For example, two bladders may be used in some embodiments, and more than three bladders may be used in other embodiments.

**[00135]** Referring now to FIGS. 71-74, a number of embodiments of a support section (e.g., support section 5316, 5318, 5320) including a bellows-type bladder construction (as in the support section 5500, for example) are shown. In FIG. 71, an embodiment 7100 includes a bellows-type inflatable bladder 7110. The bladder 7110 may be embodied as shown in FIGS. 55-56 and described above, for example. A rigid or semi-rigid panel 7118 is supported by the bladder 7110. A non-inflatable support portion 7114 is supported by the panel 7118. When the bladder 7110 inflates, the panel 7118 pivots about a hinge point 7112 to position a top surface 7116 of the non-inflatable portion 7114 at the desired lateral tilt angle as described above.

**[00136]** A sensor 7120 is mounted to the panel 7118 and configured to measure the lateral tilt angle 7122 as the inflatable bladder 7110 inflates and/or after the bladder 7110 is inflated. The sensor 7120 may be embodied as, for example, an accelerometer, inclinometer, ball switch, or other suitable type of angle sensor. The sensor 7120 communicates the angle data to a control system (e.g., the control system 5328) as described above. The sensor 7120 may be embedded in the non-inflatable portion 7114, in some embodiments.

**[00137]** In FIG. 72, an embodiment 7200 similar to the embodiment 7100 is shown. However, rather than an angle sensor mounted to the panel 7118, the embodiment 7200 includes a string potentiometer 7210, which is mounted to a base portion 7216 of the bellows bladder 7110. A distal end 7214 of the string 7212 is attached to the panel 7118. As the bladder 7110 inflates, the string potentiometer 7210 measures the distance traveled by the panel

7118 based on the change in length of the string 7212. The data generated by the string potentiometer 7210 is processed (e.g., by the control system 5328) to determine the angle 7122.

**[00138]** In FIG. 73, an embodiment 7300 utilizes a pair of sensors 7310, 7312, which are embedded in the interior region of the bellows bladder 7110, to monitor the lateral tilt angle. While the panel 7118 and support portion 7114 are omitted from FIG. 73, it should be understood that one or both of the panel 7118 and the support portion 7114 may be included in some versions of the embodiment 7300.

**[00139]** The sensors 7310, 7312 are each mounted to the internal side of the base portion 7216 of the bellows bladder 7110. The sensors 7310, 7312 are ultrasonic or laser sensors that transmit a signal through the interior region of the bellows bladder 7110 and vertically upwardly toward an internal side of the top portion 7314. As a result of the signal propagation, the output of the sensors 7310, 7312 is used to determine the vertical height from the base surface 7216 to the top surface 7316 at the locations of the sensors. The difference in the vertical heights measured by the two sensors 7310, 7312 is analyzed (e.g., by the control system 5328) to determine the angle 7122. While two sensors are shown in the embodiment 7300, it should be understood that any number of sensors may be used. Further, the spacing between the sensors 7310, 7312 may be varied according to the requirements of a particular design.

**[00140]** In FIG. 74, another version of an internal angle sensor 7410 is shown. The sensor 7410 is constructed as a vertical column of alternating portions of crushable/deformable foam 7412, 7416, 7420, 7424 and electrical switches 7414, 7418, 7422. The sensor 7410 extends vertically upwardly from the base portion 7216 to the top surface 7314, within the interior region of the bladder 7110. When the bladder 7110 is fully inflated, all of the switches 7414, 7418, 7422 are open. When the bladder 7110 is deflated, all of the switches 7414, 7418, 7422 are closed. In other words, as the angle 7122 increases, the electrical signals generated by the sensor 7410 decrease, and vice versa. The data generated by the sensor 7410 can thus be processed (e.g., by the control system 5328) to determine the angle 7122.

**[00141]** Referring now to FIG. 75, an embodiment 7500 of a person support apparatus includes a number of support sections 7510, 7512, 7514, which are inflatable to provide the progressive lateral tilt angle as described above. The person support apparatus 7500 is in communication with a weighing system 7516. In general, the weighing system 7516 includes sensors, a processor, and computer instructions executable by the process to determine the weight of a person 7518 positioned on the person support apparatus 7500. For example, the sensors of the weighing system 7516 may be embodied as load cells mounted to a support

frame supporting the person support apparatus 7500. Some examples of beds with integrated weighing systems are disclosed in, for example, U.S. Patent No. 4,934,468.

**[00142]** An air system 7520 supplies and controls the amount of air pressure delivered to each of the support sections 7510, 7512, 7514 by conduits 7522, 7524, 7526, respectively. The air system 7520 receives person weight information from the weighing system 7516 via a data communication link 7528. Instructions executable by the air system 7520 (e.g., by a processor thereof) determine the appropriate amount of air pressure to deliver to each of the support sections 7510, 7512, and 7514 based on the person's weight as detected by the weighing system 7516 and the desired lateral tilt angle of each of the sections 7510, 7512, 7514. To do this, the air system may, for example, consult a look-up table or database that maps person weights, tilt angles, and air pressures. Such mappings may be determined in advance, e.g., through experimentation or through mathematical calculations. In one example, the weighing system 7516 detects the person 7518's weight as 300 pounds. In response, the air system 7520 supplies air pressure at 9 inches of water to the sections 7510 and 7512, and supplies air pressure at 5 inches of water to the section 7514. In another example, the weighing system 7516 detects the person 7518's weight as 151 pounds. In response, the air system 7520 supplies air pressure at 6 inches of water to the sections 7510 and 7512, and supplies air pressure at 5 inches of water to the section 7514.

**[00143]** Referring now to FIGS. 76-77, an embodiment 7600 of a support section for a person support apparatus, which may be used as a middle portion 5414A, 5414B, for example, is shown. The support section 7600 includes a substantially triangularly shaped non-rigid material 7610 and a pair of differently-sized air bladders 7612, 7614 coupled to the material 7610. The material 7610 may be constructed of, for example, a type of nylon. The air bladders 7612, 7614 may be coupled to the material 7610 by RF welding or other suitable fastening technique. The bladder 7614 is larger than the bladder 7612 (e.g., the bladder 7614 has a larger diameter than the bladder 7612). The bladders 7612, 7614 are spaced from one another so that the bladder 7612 is positioned nearer to the vertex of the lateral tilt angle 7616. The spacing of the bladders 7612, 7614 relative to the material 7610 and the size difference between the bladder 7612 and the bladder 7614 allow the support section 7600 to assume a substantially triangular shape when the bladders 7612, 7614 are inflated (FIG. 76) and a substantially flat shape when the bladders 7612, 7614 are deflated (FIG. 77).

**[00144]** Referring now to FIGS. 78-80 and FIG. 81, an embodiment 7800 of a person support apparatus is shown. The person support apparatus 7800 includes a base 7810, a number

of support sections 7812, 7814, 7816 supported by the base 7810, and a side member 7818 supported by the base 7810. Each of the support sections 7812, 7814, 7816 includes, supported between the base 7810 and a top surface 7822, 78243, 7826, 7828, a three-dimensional matrix of longitudinal or log-shaped bladders 7820. The bladders 7820 are arranged in columns of vertically stacked bladders, where the columns are positioned adjacent one another across the lateral width of the support section 7812, 7814, 7816. The top surface 7822, 7824, 7826, 7828 may be constructed of foam or fabric, for example. A seam 7830 allows the top surface 7828 to move independently of the top surfaces 7822, 7824, 7826.

**[00145]** The air pressure within each of the bladders 7820 can be independently adjusted to create the desired progressive lateral tilt angle as described above. That is, a control system may control the inflation and deflation of each individual bladder 7820 independently of the other bladders. For example, as shown in FIG. 79, bladders that are nearer to the seam 7830 and thus nearer to the vertex of the lateral tilt angle may be inflated to a lesser degree than the bladders 7820 that are further away from the seam 7830. When all of the bladders 7820 are inflated by the same amount, the support section 7800 assumes a substantially flat position as shown in FIG. 80. As shown in FIG. 78, the bladders of the different sections 7812, 7814, 7816 may have different lengths. For example, the bladders 7814 may be longer in length than the bladders 7812, and the bladders 7816 may be longer in length than the bladders 7814. Illustratively, the bladders of each of the sections 7812, 7814, 7816 have the same or similar diameter. However, it should be understood that the bladder diameters may differ in other embodiments. For example, the diameter of the bladders in one of the sections 7812, 7814, 7816 may be different than the diameter of the bladders in one or more of the other sections 7812, 7814, 7816.

**[00146]** FIG. 81 illustrates a person support apparatus 8100 that is similar to the support section 7800, except that the support section 8100 has a number of bladder matrix subsections 7818. The bladder matrix subsections 7818 can be grouped together (e.g., by hook and loop fasteners or other fastening techniques) to form the bladder sections 7812, 7814, 7816. As such, the progression of the lateral tilt angle described herein can be controlled with a finer degree of granularity. Additionally, the size of the bladder sections 7812, 7814, 7816 can be dynamically adjusted (e.g., to accommodate differently-sized persons, for different therapeutic purposes, or other reasons).

**[00147]** Referring now to FIGS. 82-85, an embodiment 8200 of a person support apparatus includes a base 8210 and a number of support sections 8218, 8220, 8222 supported

by the base 8210. The support section 8218 includes a pair of side by side cylindrically-shaped pleated bladders 8212, 8214 and a non-inflatable panel 8216 supported by the bladders 8212, 8214. Each of the support sections 8220, 8222 is similarly configured. The air pressure in the bladders 8212, 8214 is selectively adjustable to alter the respective vertical heights of the bladders 8212, 8214 to achieve different angular orientations of the top surface 8228 of the non-inflatable structure 8216. The structure 8216 has a pair of recesses 8224, 8226 in its lower surface, which are sized to receive and retain a top portion of the bladders 8212, 8214, respectively. As shown in FIG. 83, the internal air pressure in the bladder 8214 is higher than the pressure in the bladder 8212, resulting in a lateral tilt toward the left side of the page. In FIG. 84, the pressure in the bladder 8212 is higher than the pressure in the bladder 8214, resulting in a lateral tilt toward the right side of the page. In FIG. 85, both of the bladders 8212, 8214 are at a medium pressure, resulting in a substantially flat surface 8228. To control the pressures in the bladders 8212, 8214, the bladders 8212, 8214 are fluidly coupled to a control system as described above.

**[00148]** Referring now to FIG. 86, a person support apparatus 8600 includes a support structure 8610, which is configured to provide a progressive lateral tilt angle or “ramp” shape as described herein. In the embodiment 8600, side members 8612, 8618, 8622 are positioned along the vertex side of the structure 8610 so as to prevent a person rotated by the structure 8610 from exiting the structure unintentionally. The side members each have length that is substantially less than the length of the support structure 8610, leaving gaps therebetween through which the person may exit the support structure 8610 if desired. As shown by the dashed lines in FIG. 86, such gaps may be filled by additional side members 8614, 8620 to form a continuous support member if desired. The support members 8612, 8618, 8622, 8614, 8620 may be constructed of inflatable bladders, such that the support members 8612, 8618, 8622, 8614, 8620 only need to be inflated when they are needed (e.g., when the support structure 8610 is in a lateral tilt position). Accordingly, the side members 8614, 8620 may be deflated, e.g., to allow egress, and inflated, as needed.

**[00149]** Referring now to FIG. 87, a person support apparatus 8700 includes a support structure 8710, which is configured to provide the progressive lateral tilt or “ramp” shape as described above, and a side member 8712. The side member 8712 has a length that is less than the entire length of the support structure 8710. As such, ingress and egress are permitted through the area in which the side member 8712 is not present.

**[00150]** Referring now to FIGS. 88-89, a person support apparatus 8800 includes a number of support sections 8812, 8816, 8818 and a side member 8820. Each of the support sections 8812, 8816, 8818 includes a wedge-shaped non-inflatable support portion 8810, an inflatable portion 8822 supported by the portion 8810, a stiffener plate 8824 supported by the inflatable portion 8822, and a top portion 8812. In the embodiment 8800, the inflatable portion 8822 of each of the support sections 8812, 8816, 8818 is deflated to drop a person down into the progressive lateral tilt position (rather than raising the person up into the lateral tilt position). To accomplish the progressive lateral tilt position, the size of the wedge 8810 is different for each of the sections 8812, 8816, 8818 (to provide the different lateral tilt angles as described herein). FIG. 88 shows the person support apparatus 8800 with the inflatable portion 8822 deflated, while FIG. 89 shows the inflatable portion 8822 inflated.

**[00151]** Referring now to FIG. 90, a person support apparatus 9000 has the same or similar construction as the person support apparatus 7800, except that the three dimensional bladder matrix includes spherical bladders 9010 rather than longitudinal or log-shaped bladders. The spherical bladders 9010 are vertically stacked and selectively inflatable to achieve the desired lateral tilt position.

**[00152]** Referring now to FIGS. 91-93, an embodiment 9100 of a person support apparatus includes a base 9110 and two-dimensional matrix of can-shaped or upright vertical bladders 9416. A row of bladders 9114 is selectively inflatable to form a side bolster or side member. The arrangement of bladders 9116 allows a high degree of customization of the progressive lateral tilt position. In the illustrative embodiment, all of the bladders 9112, 9114 are manufactured to have at least the same maximum vertical height but the height of the individual bladders is varied by a control system as described herein, to achieve the desired lateral tilt angles. For example, as shown in FIG. 92, the progressively taller height of the bladders 9210, 9212, 9214, 9216 is due to the degree to which each of these bladders is inflated.

**[00153]** Referring now to FIG. 94, an embodiment 9400 of a person support apparatus includes a support structure 9412 and a pair of side members 9414, 9416. Each of the side members 9414, 9416 has substantially the same length as the length of the base 9410 and thereby can prevent the person from unintentionally exiting the structure 9412.

**[00154]** Referring now to FIG. 95, a method 9500 for controlling the lateral tilt angle of a support section (e.g., the support sections 5316, 6318, 5320 of FIG. 53) is shown. The method 5300 may be embodied as computerized instructions, modules, or routines, which may be executed by a processor (by the air control system 5328, for example). Laterally angled support

apparatuses can have multiple sections that provide different lateral angles above the horizontal, as described herein. To provide some forms of therapy, or for other reasons, the lateral angle may be smallest toward the foot end of the support apparatus and progressively increase toward the head end of the support apparatus. This progression of increasingly greater lateral angles can allow a person's head to rotate laterally a desired amount while still providing a comfortable and stable rest surface for the person.

**[00155]** Some embodiments include a static implementation, in which the progressive lateral tilt angles are established at a point in time (e.g., at manufacture) and then maintained throughout the use of the person support apparatus. Other embodiments include a dynamic implementation, in which control algorithms are used to move the person support apparatus in and out of the progressive lateral tilt position from time to time as needed or desired. For example, control algorithms may wait until after the person using the support apparatus has fallen asleep to implement the progressive lateral tilt position, and then return the support apparatus to the flat position before the person wakes up. In either case, controlling the difference in the lateral tilt angles of adjacent sections of the person support apparatus can, among other things, reduce the risk of discomfort. In static implementations, the person support apparatus can be designed and/or customized so that the difference in the lateral tilt angles of adjacent support sections (which may be referred to herein as the "delta") is minimized or at least does not exceed a defined threshold value (which may be referred to herein as the "maximum delta." In dynamic implementations, the control algorithms can monitor lateral tilt angle change requests and either minimize the delta or enforce the maximum delta while the person support apparatus is transitioning from one position to another (e.g., from a flat position to a progressive lateral tilt position or vice versa).

**[00156]** In FIG. 95, the person support apparatus control system (e.g., control system 5328) monitors for and detects requests to change the lateral angle of one or more support sections (e.g., section(s) 5316, 5318, 5320) of the person support apparatus, at block 9510. Such requests may come from a user (e.g., by activation of a touchscreen control to initiate the progressive lateral tilt position) or an automated process (e.g., in response to expiration of a timer). If a lateral angle change request is received, the system begins to execute the requested angle change at block 9512 (e.g., by inflating/deflating bladders as needed). While executing the angle change request, the system determines and monitors the current lateral angles of the support sections (e.g., the support section that is the subject of the request and the current lateral angles of each of the adjacent support sections), at block 9514. To do this, the system receives

and analyzes sensor inputs that indicate the current lateral angles. Such inputs may be provided to the system by one or more angle sensors (e.g., accelerometers, inclinometers, ball switches, etc.) that are mounted to the respective support sections in, for example, any of the manners described herein. At block 9516, the system determines the difference (e.g., by mathematical subtraction) between the requested lateral angle and the current lateral angle of the support section being adjusted and each of its adjacent support sections. At block 9518, the system compares the difference between the requested angle and the current angles to the aforementioned maximum delta. In some cases, the maximum delta may be defined differently for different support sections, while in other cases, the maximum delta may be the same for all of the support sections. For instance, the maximum delta for a head support section with respect to its adjacent (e.g., seat) section may be larger than the maximum delta for the seat section with respect to the adjacent foot section. If the system determines that the lateral angle difference exceeds the maximum delta, the system adjusts the lateral angles of the support sections as needed at block 9520, and returns to block 9514. At block 9520, the system adjusts the lateral angle of one or more of the support sections (e.g., the support section for which the angle change is requested at block 9510 and/or the lateral angle(s) of one or more of the adjacent support sections). For example, if the request is to increase the lateral angle of the head support section, and the lateral angle difference between the requested angle and the current lateral angle of the adjacent (e.g., seat) section is greater than the maximum delta, the system may increase the lateral angle of the adjacent section. If the angle difference does not exceed the maximum delta, the system continues executing the requested angle change, at block 9522, and then ends the method 950 or returns to block 9510 as shown.

**[00186]** While certain features have been described in the context of certain illustrative embodiments, it should be understood that such features may be adopted or applied to any of the disclosed embodiments or to other embodiments.

**[00187]** The above embodiments may be described in terms of functional block components and various processing steps. Such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions. For example, embodiments may employ various integrated circuit components, e.g., memory elements, processing elements, logic elements, look-up tables, and the like, which may carry out a variety of functions under the control of one or more processors, microprocessors or other control devices. Similarly, where the elements of the above embodiments are implemented using software programming or software elements the embodiments may be implemented with

any programming or scripting language such as C, C++, Java, assembler, or the like, with the various algorithms being implemented with any combination of data structures, objects, processes, routines or other programming elements. Furthermore, the embodiments could employ any number of conventional techniques for electronics configuration, signal processing and/or control, data processing and the like. The word mechanism may be used broadly and is not limited to mechanical or physical embodiments, but can include software routines in conjunction with processors, etc.

**[00188]** The particular implementations shown and described herein are illustrative examples of the invention and are not intended to otherwise limit the scope of the invention in any way. For the sake of brevity, conventional electronics, control systems, software development and other functional aspects of the systems (and components of the individual operating components of the systems) may not be described in detail. Furthermore, the connecting lines, or connectors shown in the various figures presented are intended to represent exemplary functional relationships and/or physical or logical couplings between the various elements. It should be noted that many alternative or additional functional relationships, physical connections or logical connections may be present in a practical device. Moreover, no item or component is essential to the practice of the invention unless the element is specifically described as “essential” or “critical.” Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the embodiments.

**[00189]** The order of execution or performance of the operations in embodiments illustrated and described herein is not essential, unless otherwise specified. That is, the operations may be performed in any order, unless otherwise specified, and embodiments as described may include additional or fewer operations than those disclosed herein. For example, it is contemplated that executing or performing a particular operation before, contemporaneously with, or after another operation is within the scope of aspects of the invention.

**[00190]** Embodiments may be implemented with computer-executable instructions. The computer-executable instructions may be organized into one or more computer-executable components or modules. Aspects of the disclosure may be implemented with any number and organization of such components or modules. For example, aspects of the disclosure are not limited to the specific computer-executable instructions or the specific components or modules illustrated in the figures and/or described herein. Other embodiments may include different

computer-executable instructions or components having more or less functionality than illustrated and described herein.

**[00191]** Many other embodiments of the present disclosure are also envisioned. For example, a method comprises determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; displaying a proposed configuration of a person support structure corresponding to the care protocol for a caregiver to approve; and upon approval by the caregiver, implementing the configuration. In another contemplated embodiment, the configuration causes the person support structure to raise a first section of the person support structure such that the first section forms an angle of greater than  $0^\circ$  with respect to the reference plane. In another contemplated embodiment, the configuration causes the person support structure to laterally tilt an occupant supported on the person support structure to a side such that the occupant is at an angle of greater than  $0^\circ$  with respect to the reference plane. In another contemplated embodiment, the configuration causes the person support structure to move to at least one of a Trendelenburg and reverse Trendelenburg position. In another contemplated embodiment, the configuration causes a therapy to be initiated. In another contemplated embodiment, the therapy includes heat and moisture regulating therapy. In another contemplated embodiment, the therapy includes continuous lateral rotation therapy. In another contemplated embodiment, the therapy includes at least one of percussion therapy and vibration therapy. In another contemplated embodiment, the proposed configuration is modified as a function of a second input indicative of the orientation of a person supported on the person support structure. In another contemplated embodiment, the proposed configuration is modified as a function of a second input indicative of the position of a person supported on the person support structure. In another contemplated embodiment, the method further comprises the steps of: receiving an input indicative of the sleep state of the person supported on the person support structure; and if the person is waking up, restoring the person support structure to a previous configuration. In another contemplated embodiment, the person support structure is configured upon an occupant reaching a predetermined sleep stage. In another contemplated embodiment, the method further comprises the steps of: receiving a configuration override command; and restoring the person support structure to a previous configuration. In one contemplated embodiment, the configuration override command is communicated from a remote location. In another contemplated embodiment, the configuration override command is communicated when a CPR function is activated. In another contemplated embodiment, the configuration override command is communicated from a GUI coupled to the

person support structure. In another contemplated embodiment, the method further comprises the step of notifying a caregiver if the presence of a material would aggravate an adverse condition. In another contemplated embodiment, the method further comprises the steps of: receiving an input indicative of a material proximate to the person supported on the person support structure determining if the material increases the person's risk for developing an adverse condition.

**[00192]** In another example, a method comprises receiving a signal indicative of a physiological characteristic; comparing the signal to a threshold to determine if an adverse event is in progress; and upon detecting that an adverse event is in progress, initiating an intervention to stop the adverse event. In one contemplated embodiment, the second intervention includes increasing the magnitude of the first intervention. In another contemplated embodiment, the second intervention includes alerting a caregiver.

**[00193]** In another example, a person support surface comprises a mattress ticking and a mattress core. The mattress core is enclosed by the mattress ticking and includes at least one fluid bladder configured to selectively protrude from the person contacting surface and support a portion of at least one of the neck and the upper back of an occupant supported on the person support surface. In one contemplated embodiment, the at least one fluid bladder is configured to support the cervical vertebrae of an occupant. In another contemplated embodiment, the at least one fluid bladder is configured to protrude a distance of at least about 70mm from the occupant facing surface. In another contemplated embodiment, the at least one fluid bladder is configured to support the scapula of an occupant. In another contemplated embodiment, the at least one fluid bladder is configured to protrude a distance of at least about 20mm from the occupant facing surface. In another contemplated embodiment, the at least one fluid bladder is configured to protrude a distance of about 20mm to about 30mm from the occupant facing surface. In another contemplated embodiment, the at least one fluid bladder is configured to protrude a distance of less than about 30mm from the occupant facing surface. In another contemplated embodiment, the at least one fluid bladder is configured to laterally tilt an occupant's head when inflated. In another contemplated embodiment, the at least one fluid bladder is inflated upon detecting the onset of an adverse condition.

**[00194]** In another example, a method comprises determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; sensing a first physiological characteristic of a person supported on a person support structure; sensing a second physiological characteristic of the person; comparing the first physiological

characteristic to the second physiological characteristic; if the difference between the first physiological characteristic and second physiological characteristic is outside a predefined range, configuring the person support structure as a function of the care protocol.

[00195] In another example, a method comprises determining a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; sensing a first physiological characteristic of a person supported on a person support structure; sensing a second physiological characteristic of the person; comparing the first physiological characteristic to the second physiological characteristic; if the difference between the first physiological characteristic and second physiological characteristic is outside a predefined range, alerting a caregiver that an adverse condition is going to occur.

[00196] In an example, a person support apparatus to support a person in at least a horizontal position includes a plurality of support sections arranged along a length of the person support apparatus, where each of the support sections has a support surface to support a body portion of the person and an inflatable portion supporting the support surface, where the inflatable portion of the support section is selectively inflatable and deflatable to position the support surface of the support section in a tilt position in which the support surface is angled at a maximum lateral tilt angle and position the support surface in a flat position in which the support surface is angled at a substantially flat angle, wherein the support surfaces of at least two of the support sections have different maximum lateral tilt angles.

[00197] The plurality of support sections may include a head section to support the person's head, a seat section to support the person's torso, and a foot section to support the person's feet, where the maximum lateral tilt angle of the support surface of the head section is greater than the maximum lateral tilt angle of the support surface of the seat section and the maximum lateral tilt angle of the seat section is greater than the maximum lateral tilt angle of the foot section. The inflatable portion of each of the support sections may be inflated to position the support surface in the tilt position and deflated to position the support surface in the flat position. The inflatable portion of each of the support sections may be deflated to position the support surface in the tilt position and inflated to position the support surface in the flat position. Each of the support sections may include a non-inflatable support member in cooperation with the inflatable portion to selectively position the support surface of the support section in the tilt position and the flat position. The inflatable portion may be supported by the non-inflatable support member. The inflatable portion may support the non-inflatable support member. The inflatable portion may include a bellows-shaped bladder. The bellows-shaped

bladder may be inflatable to position the support surface of the support section at the maximum lateral tilt angle by rotating the support surface about a longitudinal axis of the person support apparatus located adjacent a first side of the person support apparatus.

**[00198]** The person support apparatus may include a second bellows-shaped bladder supported by the first bellows shaped bladder and inflatable to position the support surface of the support section at the maximum lateral tilt angle by rotating the support surface about a second longitudinal axis of the person support apparatus located adjacent a second side of the person support apparatus, wherein the second side of the person support apparatus is laterally spaced from the first side.

**[00199]** The person support apparatus may include a plurality of baffles in an interior region of the bellows-shaped bladder, wherein each of the baffles has a different length. The support section may include a side member positioned adjacent a vertex of the maximum lateral tilt angle of the support surface. The side member may extend along the length of the person support apparatus and the side member may have a length that is less than the length of the person support apparatus.

**[00200]** The person support apparatus may include a cover sized to enclose the support sections in an interior region, where the cover includes expandable sections corresponding to the support sections to accommodate the support sections when the support surface of each of the support sections is in the tilt position and when the support surface of each of the support sections is in the flat position. The inflatable portion of each of the support sections may include a multiple-chamber bladder assembly, and each of the bladders in the multiple-chamber bladder assembly may be inflatable to a different height. Each of the bladders of the multiple-chamber bladder assembly may be substantially log shaped and the bladders may be in fluid communication with each other. Each support section may include a sensor to measure the lateral tilt angle of the support surface of the support section, where the sensor is coupled to the support section. The sensor may be enclosed within an interior region of the support section. The person support apparatus may be in communication with an air control system and a person weighing system to determine the weight of a person positioned on the person support apparatus, where the air control system adjusts the amount of air pressure supplied to the inflatable portion of each of the support sections to achieve the maximum tilt angle of the support surface of the support section in response to a weight detected by the person weighing system. The inflatable portion of each of the support sections may include a three-dimensional

matrix defined by a plurality of horizontally aligned columns of vertically stacked inflatable bladders.

**[00201]** Each of the inflatable bladders may be configured to assume a log-like shape when inflated. Each of the inflatable bladders may be configured to assume a sphere-like shape when inflated. The inflatable portion of each of the support sections may include a two-dimensional matrix including a plurality of rows and columns of horizontally aligned inflatable bladders, where the maximum height of the bladders is adjustable to achieve the maximum tilt angle of the support section. The inflatable portion may include a pair of laterally-spaced inflatable bladders and a non-inflatable member supported by the pair of laterally-spaced inflatable bladders, where the non-inflatable member supports the support surface and the support surface assumes the tilt position when both of the inflatable bladders are at least partially inflated and one of the inflatable bladders is inflated to a different height than the other inflatable bladder. Each of the support sections may include a wedge-shaped non-inflatable base and the inflatable portion may be supported by the wedge-shaped non-inflatable base.

**[00202]** Any theory, mechanism of operation, proof, or finding stated herein is meant to further enhance understanding of principles of the present disclosure and is not intended to make the present disclosure in any way dependent upon such theory, mechanism of operation, illustrative embodiment, proof, or finding. It should be understood that while the use of the word preferable, preferably or preferred in the description above indicates that the feature so described can be more desirable, it nonetheless cannot be necessary and embodiments lacking the same can be contemplated as within the scope of the disclosure, that scope being defined by the claims that follow.

**[00203]** In reading the claims it is intended that when words such as “a,” “an,” “at least one,” “at least a portion” are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language “at least a portion” and/or “a portion” is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

**[00204]** It should be understood that only selected embodiments have been shown and described and that all possible alternatives, modifications, aspects, combinations, principles, variations, and equivalents that come within the spirit of the disclosure as defined herein or by any of the following claims are desired to be protected. While embodiments of the disclosure have been illustrated and described in detail in the drawings and foregoing description, the same are to be considered as illustrative and not intended to be exhaustive or to limit the disclosure to

the precise forms disclosed. Additional alternatives, modifications and variations can be apparent to those skilled in the art. Also, while multiple inventive aspects and principles can have been presented, they need not be utilized in combination, and various combinations of inventive aspects and principles are possible in light of the various embodiments provided above.

## WHAT IS CLAIMED IS:

1. A method, comprising:
  - receiving an input indicative of a person's level of risk for developing an adverse condition;
  - selecting a care protocol based on the input;
  - communicating a proposed configuration of a person support structure corresponding to the care protocol for a caregiver to approve; and
  - upon approval by the caregiver, configuring the person support structure in accordance with the care protocol.
2. The method of claim 1, wherein the configuration causes the person support structure to raise a first section of the person support structure such that the first section forms an angle of greater than  $0^{\circ}$  with respect to the reference plane.
3. The method of claim 1 or claim 2, wherein the configuration causes the person support structure to laterally tilt an occupant supported on the person support structure to a side such that the occupant is at an angle of greater than  $0^{\circ}$  with respect to the reference plane.
4. The method of any of the preceding claims, wherein the configuration causes the person support structure to move to at least one of a Trendelenburg and reverse Trendelenburg position.
5. The method of any of the preceding claims, wherein the configuration causes a therapy to be initiated.
6. The method of claim 5, wherein the therapy includes heat and moisture regulating therapy.
7. The method of claim 5 or claim 6, wherein the therapy includes continuous lateral rotation therapy.
8. The method of any of claims 5-7, wherein the therapy includes at least one of percussion therapy and vibration therapy.

9. The method of any of the preceding claims, wherein the proposed configuration is modified as a function of a second input indicative of the orientation of a person supported on the person support structure.
10. The method of any of the preceding claims, wherein the proposed configuration is modified as a function of a second input indicative of the position of a person supported on the person support structure.
11. The method of any of the preceding claims further comprising the steps of:  
receiving an input indicative of the sleep state of the person supported on the person support structure; and  
if the person is waking up, restoring the person support structure to a previous configuration.
12. The method of any of the preceding claims, wherein the person support structure is configured upon an occupant reaching a predetermined sleep stage.
13. The method of any of the preceding claims further comprising the steps of:  
receiving a configuration override command; and  
restoring the person support structure to a previous configuration.
14. The method of claim 13, wherein the configuration override command is communicated from a remote location.
15. The method of claim 13 or claim 14, wherein the configuration override command is communicated when a CPR function is activated.
16. The method of any of claims 13-15, wherein the configuration override command is communicated from a GUI coupled to the person support structure.
17. The method of any of the preceding claims further comprising the step of notifying a caregiver if the presence of a material would aggravate an adverse condition.

18. The method of any of the preceding claims further comprising the steps of:
  - receiving an input indicative of a material proximate to the person supported on the person support structure
  - determining if the material increases the person's risk for developing an adverse condition.
19. A method, comprising:
  - receiving an input signal indicative of a physiological characteristic;
  - determining if an adverse event is in progress based on the input signal;
  - upon determining that an adverse event is in progress, initiating a first intervention to stop the adverse event;
  - receiving a second input signal indicative of the physiological characteristic at a time after the first intervention is initiated;
  - determining if the adverse event is still in progress;
  - upon determining that the adverse event is still in progress, initiating a second intervention.
20. The method of claim 19, wherein the second intervention includes increasing the magnitude of the first intervention.
21. The method of claim 19 or claim 20, wherein the second intervention includes alerting a caregiver.
22. A occupant support surface, comprising: a mattress ticking; and a mattress core enclosed by the mattress ticking and including an occupant facing surface and at least one fluid bladder configured to selectively protrude from the occupant facing surface to support a portion of at least one of the neck and the upper back of an occupant supported on the occupant support surface.
23. The occupant support surface of claim 22, wherein the at least one fluid bladder is configured to support the cervical vertebrae of an occupant.

24. The occupant support surface of claim 22 or claim 23, wherein the at least one fluid bladder is configured to protrude a distance of at least about 70mm from the occupant facing surface.
25. The occupant support surface of any of claims 22-24, wherein the at least one fluid bladder is configured to support the scapula of an occupant.
26. The occupant support surface of any of claims 22-25, wherein the at least one fluid bladder is configured to protrude a distance of at least about 20mm from the occupant facing surface.
27. The occupant support surface of any of claims 22-26, wherein the at least one fluid bladder is configured to protrude a distance of about 20mm to about 30mm from the occupant facing surface.
28. The occupant support surface of any of claims 22-26, wherein the at least one fluid bladder is configured to protrude a distance of less than about 30 mm from the occupant facing surface.
29. The occupant support surface of any of claims 22-26, wherein the at least one fluid bladder is configured to laterally tilt an occupant's head when inflated.
30. The occupant support surface of any of claims 22-26, wherein the at least one fluid bladder is inflated upon detecting the onset of an adverse condition.
31. A method, comprising:
- receiving an input indicative of a person's level of risk for developing an adverse condition;
  - selecting a care protocol based on the level of risk;
  - receiving an input signal indicative of a first physiological characteristic of a person supported on a person support structure at a first time;
  - receiving an input signal indicative of a second physiological characteristic of the person at a second time;

comparing the first physiological characteristic to the second physiological characteristic;

if the difference between the first physiological characteristic and second physiological characteristic is outside a predetermined range, configuring the person support structure as a function of the care protocol.

32. A method, comprising:

receiving an input signal indicative of a person's level of risk for developing an adverse condition;

selecting a care protocol based on the level of risk;

receiving an input signal indicative of a first physiological characteristic of a person supported on a person support structure at a first time;

receiving an input signal indicative of a second physiological characteristic of the person at a second time;

comparing the first physiological characteristic to the second physiological characteristic;

if the difference between the first physiological characteristic and second physiological characteristic is outside a predetermined range, alerting a caregiver that an adverse condition is going to occur.

33. A system, comprising:

a person support structure configured to support a person thereon;

a sensor configured to sense the orientation of a person's head with respect to a reference plane;

a control system configured to control a function of the person support structure in response to the input from the sensor to maintain the person's head within a range of orientations.

34. The system of claim 33, wherein the sensor includes an RFID sensor and the person support structure includes an RFID reader.

35. The system of claim 33 or claim 34, wherein the sensor is coupled to a person's head.

36. The system of any of claims 33-35, wherein the sensor is at least one of coupled to a person's eyes, ears, nose, and upper respiratory tract, and worn by a person.
37. The system of any of claims 33-36, wherein the control system causes the support structure to laterally rotate a person so that the sensor indicates that the orientation of a person's head is at least  $\pm 30$  degrees with respect to vertical.
38. The system of any of claims 33-37, wherein the control system activates an alarm if a person's head is below a predetermined orientation threshold.
39. A support system defining a sleep surface configured to support a user thereon, said support system comprising a plurality of support pieces, each support piece of the plurality of support pieces defining a respective support plane having a lateral rotational angle with respect to a base surface of the support piece, wherein a first support piece of the plurality of support pieces defines a first support plane having a lateral rotational angle different from the lateral rotational angles of the other support planes.
40. A method, comprising:  
receiving an input signal indicative of a physiological characteristic of a person supported on a person support structure;  
determining if an apnea event is in progress based on the input signal;  
if an apnea event is in progress, generating an intervention.
41. The method of claim 40, wherein the intervention is specified by a facility care protocol.
42. The method of claim 40 or claim 41, wherein the intervention is specified by a person's care plan.
43. The method of any of claims 40-42, wherein the intervention includes alerting a caregiver.
44. The method of any of claims 40-43, wherein the intervention includes activating a therapy.

45. The method of claim 44, wherein the therapy includes continuous lateral rotation therapy
46. The method of claim 44 or claim 45, wherein the therapy includes at least one of percussion and vibration therapy.
47. The method of any of claims 40-46, wherein the intervention includes re-configuring the person support structure.
48. The method of claim 47, wherein the person support structure includes an upper frame movably supported above a lower frame by a lift mechanism, the upper frame being configured to move between a generally horizontal position and a reverse Trendelenburg position in response to detection of an apnea event.
49. The method of claim 47 or claim 48, wherein the person support structure includes an upper frame movably supported above a lower frame by a lift mechanism, the upper frame being configured to move between a generally horizontal position and a chair position in response to detection of an apnea event.
50. The method of any of claims 47-49, wherein the person support structure includes an upper frame movably supported above a lower frame by a lift mechanism, the upper frame being configured to move between a generally horizontal position and a laterally rotated position in response to detection of an apnea event, wherein the upper frame is rotated about an axis extending along the length of the upper frame when the upper frame is laterally rotated.
51. The method of any of claims 47-50, wherein the person support structure includes an upper frame movably supported above a lower frame by a lift mechanism, the upper frame being configured to move between a first position and a second position in response to detection of an apnea event, wherein a section of the upper frame is generally horizontal in the first position and inclined in the second position.
52. The method of any of claims 47-51, wherein the person support structure includes a mattress including at least one fluid bladder, the at least one fluid bladder being inflated to rotate a person's body in response to detection of an apnea event.

53. The method of any of claims 40-52, wherein the intervention includes a stimulus that causes a person to wake up.
54. The method of claim 53, wherein the stimulus includes at least one of a light, a sound, a smell, and a physical stimulus.
55. The method of any of claims 40-54, wherein the intervention includes a stimulus that causes a person to move from a deeper sleep stage to a lighter sleep stage without waking up.
56. The method of any of claims 40-55, further comprising the steps of:  
receiving a second physiological characteristic of a person supported on a person support structure;  
comparing the second physiological characteristic to a predetermined threshold to determine if an apnea event is in progress;  
if the physiological characteristic exceeds the predetermined threshold, increasing the magnitude of the intervention.
57. The method of any of claims 40-56, further comprising the steps of:  
receiving a second physiological characteristic of a person supported on a person support structure;  
determining if an apnea event is in progress based on the second physiological characteristic;  
if an apnea event is in progress, generating an alert.
58. The method of any of claims 40-57, wherein the physiological characteristic includes a person's respiration rate.
59. The method of any of claims 40-58, wherein the physiological characteristic includes a person's respiration amplitude.
60. The method of any of claims 40-59, wherein the physiological characteristic includes a person's blood oxygenation level.

61. The method of any of claims 40-60, wherein the predetermined threshold is at least about a 4% decrease in oxygen saturation.
62. The method of any of claims 40-61, wherein the predetermined threshold is less than about 69% of a person's normal breath.
63. A therapy system, comprising:  
a garment including a fluid bladder; and  
at least one rotation bladder coupled to the garment and configured to be selectively inflated to rotate a portion of a person wearing the garment between a first orientation and a second orientation.
64. The therapy system of claim 63, wherein the garment includes a sequential compression device.
65. The therapy system of claim 63, wherein the garment includes a chest wall oscillation device.
66. The therapy system of claim 63, further comprising a fluid supply configured to supply fluid to both the fluid bladder and the rotation bladder.
67. The therapy system of claim 63, wherein the rotation bladder is configured to cause the portion of the person to rotate a magnitude of at least 30° with respect to a reference upon detection of an adverse condition.
68. A person support system, comprising:  
a person support structure configured to support a person thereon;  
an input device configured to determine the sleep state of a person supported on the person support structure; and  
a control system configured to control a function of the person support structure as a function of the sleep state of a person.
69. The person support system of claim 68, wherein the person support structure includes an upper frame movably supported above a lower frame by a lift mechanism, the control system

causing at least a portion of the upper frame to move with respect to the lower frame as a function of the sleep state.

70. The person support system of claim 69, wherein a section of the upper frame is moved between a substantially horizontal position and an inclined position.

71. The person support system of claim 69 or claim 70, wherein the upper frame is moved between a substantially horizontal position and a reverse Trendelenburg position.

72. The person support system of any of claims 69-71, wherein the upper frame is rotated laterally about an axis extending along the length of the upper frame.

73. The person support system of claim 72, wherein the upper frame is rotated  $\pm 30^\circ$  with respect to horizontal.

74. The person support system of any of claims 69-73, wherein the upper frame is moved between a substantially planar position and a chair position.

75. The person support system of any of claims 69-74, wherein the upper frame is moved between a substantially planar position and a reclined position.

76. The person support system of any of claims 68-75, wherein the person support structure includes a mattress including a fluid bladder, wherein the fluid bladder is filled with a fluid as a function of the sleep state to cause a person supported on the mattress to rotate laterally about an axis extending along the length of the mattress.

77. The person support system of any of claims 68-76, wherein the control system activates a therapy based on the sleep state.

78. The person support system of any of claims 68-77, wherein the therapy includes continuous lateral rotation therapy.

79. The person support system of any of claims 68-78, wherein the therapy includes at least one of percussion and vibration therapy.

80. The person support system of any of claims 68-79, wherein the therapy includes temperature and moisture regulation therapy.
81. A method, comprising the steps of:  
receiving an input indicative of at least one of a person's medical history and an adverse event risk score;  
determining if a sleep apnea event is likely based on the input; and if a sleep apnea event is likely, generating an intervention.
82. The method of claim 81, wherein the intervention includes alerting a caregiver that the person has a history of sleep apnea.
83. The method of claim 81 or claim 82, wherein an apnea event is determined to be likely when the person's medical history indicates that the person has a history of sleep apnea.
84. The method of any of claims 81-83, wherein the intervention includes activating a therapy.
85. The method of any of claims 81-84, wherein the intervention includes causing a person support structure supporting the person to perform a function.
86. The method of any of claims 81-85, wherein the input is received from an electronic medical record system.
87. A method, comprising the steps of:  
receiving an input indicative of a characteristic of a person;  
determining a risk of a sleep apnea event occurring based on the input; and  
generating an intervention as a function of the risk that a sleep apnea event will occur.
88. The method of claim 87, wherein the intervention includes alerting a caregiver.
89. The method of claim 87 or claim 88, wherein the intervention includes determining a care protocol as a function of a facility input and communicating the care protocol to a caregiver for approval.

90. The method of any of claims 87-89, wherein the intervention includes activating a therapy.
91. The method of any of claims 87-90, wherein the intervention includes causing a person support structure to perform a function.
92. The method of any of claims 87-91, wherein the characteristic includes a respiration rate.
93. The method of any of claims 87-92, wherein the characteristic includes a respiration amplitude.
94. The method of any of claims 87-93, wherein the characteristic includes a person's BMI.
95. The method of any of claims 87-94, wherein the characteristic includes an intensity of the person's snore.
96. The method of any of claims 87-95, wherein the characteristic includes a circumference of the person's neck.
97. The method of any of claims 87-96, wherein the characteristic includes pauses in breathing while sleeping.
98. The method of any of claims 87-97, wherein the characteristic includes whether the person is under anesthesia.
99. The method of any of claims 87-98, wherein the characteristic includes whether the person has undergone a surgical procedure.
100. The method of any of claims 87-99, wherein the characteristic includes the type of medication the person is taking.
101. The method of any of claims 87-100, wherein the characteristic includes information from a sleep study.

102. A method, comprising the steps of:  
receiving an input indicative of a person's body position;  
receiving an input indicative of the person's medical condition;  
determining an effect that the person's position has on the medical condition;  
generating an intervention as a function of the effect.
103. The method of claim 102, wherein the person's position is sensed using a 3D sensor.
104. The method of claim 102 or claim 103, wherein the person's position is sensed using an image capture device.
105. The method of any of claims 102-104, wherein the person's medical condition is received from an electronic medical record system.
106. The method of any of claims 102-105, wherein the person's medical condition is input by a caregiver.
107. The method of any of claims 102-106, wherein the intervention is generated when the person suffers from positional sleep apnea and is laying in a supine position.
108. The method of any of claims 102-107, wherein the intervention is generated when the person suffers from gastroesophageal reflux disease and is laying in a supine position.
109. The method of any of claims 102-108, wherein the intervention includes causing the person to change their body position.
110. The method of any of claims 102-109, wherein the person is supported on a dynamic person support surface and the intervention causes the dynamic person support surface to rotate the person's body.
111. The method of any of claims 102-110, wherein the dynamic person support surface includes at least one fluid bladder that is selectively inflatable.
112. The method of any of claims 102-111, wherein the intervention includes alerting a caregiver.

113. The method of any of claims 102-112, wherein the person is supported on a bed frame including an upper frame movably supported above a lower frame by a lift mechanism, the intervention causing the upper frame to rotate about an axis extending along the length of the upper frame to rotate the person's body laterally.

114. The method of any of claims 102-113, wherein the person is supported on a bed frame including an upper frame movably supported above a lower frame by a lift mechanism, the intervention causing a portion of the upper frame to move between a substantially horizontal position and an inclined position.

115. A system, comprising:

an input device configured to receive information indicative of the sleep state of a person; and

a control system configured to determine the sleep state of the person based on the information received by the input and control a device as a function of the sleep state of a person.

116. The system of claim 115, wherein the device includes a mattress including a fluid bladder, wherein the fluid bladder is filled with a fluid as a function of the sleep state to cause a person supported on the mattress to rotate laterally about an axis extending along the length of the mattress.

117. The system of claim 115 or claim 116, wherein the device is configured to rotate a person about an axis extending along the length of the person's body.

118. The system of any of claims 115-117, wherein the device is configured to provide continuous lateral rotation therapy.

119. The system of any of claims 115-118, wherein the device is configured to provide least one of percussion and vibration therapy.

120. The system of any of claims 115-119, wherein the device is configured to provide temperature and moisture regulation therapy.

121. A person support surface configured to support a person thereon, comprising:  
a sloped surface; and  
a bolster positioned at the base of the sloped surface, the bolster being configured to maintain the person on the sloped surface.
122. The person support surface of claim 121, wherein the sloped surface includes a first section and a second section, wherein the slope of the first section and the slope of the second section are different.
123. The system of claim 122, wherein the slope of the first section is between about 20° and about 30° with respect to a reference plane and the slope of the second section is between about 10° and about 20° with respect to a reference plane.
124. The system of claim 123, further comprising a third section, the slope of the third section being between about 5° and about 15° with respect to a reference plane.
125. The system of any of claims 122-124, wherein the slope of the first section greater than about 20° with respect to a reference plane.
126. The system of any of claims 122-125, wherein the slope of the second section greater than about 10° with respect to a reference plane and less than about the slope of the first section.
127. The system of any of claims 122-126, further comprising a third section, the slope of the third section being between greater than about 5° with respect to a reference plane and less than about the slope of the second section.
128. The system of any of claims 121-127, wherein the sloped surface is wedge-shaped.
129. A method of detecting an adverse condition, comprising:  
receiving an input indicative of a physiological characteristic of a person and a posture of a person;  
determining if an adverse event that is not a positional apnea event is in progress based on the input;

if an adverse event is in progress, alerting a caregiver.

130. A method comprising:

receiving an input indicative of a person's level of risk for developing an adverse condition;

determining a proposed intervention based on the input;

communicating the proposed intervention to a caregiver for approval;

and upon approval by the caregiver, initiating an intervention.

131. The method of claim 130, wherein the intervention causes a person support structure to raise a first section of the person support structure such that the first section forms an angle of greater than  $0^\circ$  with respect to the reference plane.

132. The method of claim 130 or claim 131, wherein the intervention causes a person support structure to laterally tilt an occupant supported on the person support structure to a side such that the occupant is at an angle of greater than  $0^\circ$  with respect to the reference plane.

133. The method of any of claims 130-132, wherein the intervention causes a person support structure to move to at least one of a Trendelenburg and reverse Trendelenburg position.

134. The method of any of claims 130-133, wherein the intervention causes a therapy to be initiated.

135. The method of claim 134, wherein the therapy includes heat and moisture regulating therapy.

136. The method of claim 134 or claim 135, wherein the therapy includes continuous lateral rotation therapy.

137. The method of any of claims 134-136, wherein the therapy includes at least one of percussion therapy and vibration therapy.

138. The method of any of claims 130-137, wherein the proposed intervention is modified as a function of a second input indicative of the orientation of a person supported on a person support structure.

139. The method of any of claims 130-138, wherein the proposed intervention is modified as a function of a second input indicative of the position of a person supported on a person support structure.

140. The method of any of claims 130-139, wherein the intervention causes a person support structure to be configured upon an occupant reaching a predetermined sleep stage.

141. The method of any of claims 130-140, further comprising the step of notifying a caregiver if the presence of a material would aggravate an adverse condition.

142. The method of any of claims 130-141, further comprising the step of communicating information corresponding to the information received and the intervention to an electronic medical record database.

143. The method of any of claims 130-142, further comprising the step monitoring the intervention to ensure compliance with the proposed intervention.

144. The method of any of claims 130-143, wherein the intervention includes causing a garment to rotate a portion of the person's body.

145. A support system configured to support and laterally rotate at least a portion of a user with respect to a longitudinal axis of the support system, said support system comprising:

at least one support piece configured to form a laterally angled sleep surface having a length defined between a first edge and an opposing second edge spaced from the first edge along the longitudinal axis.

146. The support system of claim 145, wherein the at least one support piece forms a contour over the length of the laterally angled sleep surface.

147. The support system of claim 145 or claim 146, wherein the at least one support piece forms a continuously sloped sleep surface.

148. The support system of any of claims 145-147, wherein the at least one support piece is rotatable about the longitudinal axis.

149. The support system of any of claims 145-148, wherein the at least one support piece comprises a plurality of support pieces configured to collectively define the laterally angled sleep surface, a first support piece of the plurality of support pieces forming a first support plane along the longitudinal axis having a first angle of rotation with respect to a base surface of the support system and a second support piece of the plurality of support pieces forming a second support plane along the longitudinal axis having a second angle of rotation with respect to the base surface different than the first angle of rotation.

150. The support system of claim 149, wherein the plurality of support pieces have progressively greater angles of rotation along the longitudinal axis to facilitate a relatively greater rotation of an upper respiratory tract of the user and a relatively lesser rotation in a lower body of the user.

151. The support system of claim 149 or claim 150, wherein the second angle of rotation is greater than the first angle of rotation to facilitate greater rotation of an upper respiratory tract of the user supported on the second support plane than a lower body of the user at least partially supported on the first support plane.

152. The support system of any of claims 149-151, wherein each support piece of the plurality of support pieces is independently rotatable about an axis extending parallel with the longitudinal axis of the support system.

153. The support system of any of claims 149-152, wherein the first support plane is positioned at a first lateral angle of rotation of 20° to 30° with respect to a base surface of the first support piece, the second support plane is positioned at a second lateral angle of rotation of 10° to 20° with respect to a base surface of the second support piece, and a third support piece defines a third support surface positioned at a third lateral angle of rotation of 5° to 15° with respect to a base surface of the third support piece.

154. The support system of any of claims 149-153, further comprising a transitional piece positioned between adjacent support pieces of the plurality of support pieces to facilitate providing a gradual continuous transition between support planes of the adjacent support pieces.

155. The support system of any of claims 149-154, further comprising a transitional piece positioned at a transitional line where the first support piece meets with the second support piece to provide support for the user.

156. The support system of any of claims 145-155, further comprising a system control having a display configured to display information about the support system.

157. The support system of claim 156, wherein the system control comprises a processor configured to adjust angles of rotation of the support planes based at least in part on data inputted at the system control and/or data signals received from one or more sensors of the support system.

158. The support system of any of claims 145-157, further comprising a bolster positioned along a lateral side of the support system to limit lateral migration of the user.

159. The support system of claim 158, wherein at least a portion of the bolster includes a textured surface to facilitate retaining the user positioned on the sleep surface.

160. The support system of claim 158 or claim 159, wherein the bolster is formed of a formable material to provide envelopment throughout the sleep surface.

161. The support system of any of claims 158-160, further comprising a strap operatively coupled to the bolster to facilitate maintaining the user positioned on the sleep surface.

162. The support system of any of claims 149-161, wherein each support piece of the plurality of support pieces is rotatable about the longitudinal axis between a first orientation having a right side slope and a second orientation having a left side slope.

163. The support system of claim 162, further comprising a section positioned within the first support piece and coaxially aligned with the longitudinal axis to facilitate rotation of the first support piece about the longitudinal axis independently of the second support piece.

164. The support system of any of claims 145-163, further comprising at least one spacer configured to adjust the length of the support surface.

165. The support system of any of claims 145-164, wherein the support surface has a fixed length, said support system further comprising a spacer to adjust a length of the at least one support piece.

166. The support system of claim 165, wherein adjacent support pieces of the at least one support piece and the spacer are coupled together using a coupling mechanism.

167. The support system of any of claims 145-166, wherein the at least one support piece comprises an inflatable fluid bladder configured to contain a fluid.

168. The support system of claim 167, wherein an amount of fluid within the fluid bladder is controlled electronically.

169. The support system of claim 168, further comprising a coupler configured to at least one of to maintain an amount of fluid within the fluid bladder and provide support to the respective support plane.

170. The support system of any of claims 145-169, wherein a first support piece of the at least one support piece comprises a plurality of independent support wedges forming a gradation in a longitudinal slope of the sleep surface.

171. The support system of claim 170, wherein each of the plurality of independent support wedges comprises one of a formable material, a semi-rigid material, a foam material, and a fluid bladder.

172. The support system of claim 171, wherein a first support wedge of the plurality of independent support wedges defines a first support plane positioned at a first lateral angle of

rotation and a second support wedge of the plurality of independent support wedges defines a second support plane at a second lateral angle of rotation different than the first lateral angle of rotation.

173. The support system of any of claims 145-172, wherein the at least one support piece comprises a continuous support piece having a gradual density transition along the length of the sleep surface.

174. The support system of any of claims 145-172, wherein the at least one support piece comprises a plurality of support pieces configured to collectively define the laterally angled sleep surface, a first support piece of the plurality of support pieces having a first density and a second support piece of the plurality of support pieces having a second density different than the first density.

175. The support system of claim 174, wherein each support piece of the plurality of support pieces defines a support plane positioned at a substantially similar, initial lateral rotational angle,

176. A support system configured to induce a user's body to rotate laterally when sleeping to facilitate limiting the incidence of sleep apnea, said support system comprising a closed air system having at least one support piece configured to form a laterally angled sleep surface having a length defined between a first edge and an opposing second edge spaced from the first edge along a longitudinal axis of the support system, the at least one support piece comprising a pair of laterally-spaced fluid bladders coupled in communication with each other.

177. The support system of claim 176, further comprising a coupling mechanism providing fluid communication between a first interior cavity of a first fluid bladder and a second interior cavity of a second fluid bladder of the pair of laterally-spaced fluid bladders to allow fluid to move between the first interior cavity and the second interior cavity.

178. The support system of claim 176 or claim 177, wherein the closed air system comprises a plurality of support pieces, a first support piece of the plurality of support pieces forming a first support plane and including a first pair of laterally-spaced fluid bladders and a second

support piece of the plurality of support pieces forming a second support plane and including a second pair of laterally-spaced fluid bladders.

179. The support system of any of claims 176-178, wherein at least one of a first lateral angle of rotation of the first support plane and a second lateral angle of rotation of the second support plane is adjustable.

180. The support system of any of claims 176-179, wherein an amount of fluid contained within each of the first fluid bladder and the second fluid bladder is adjustable to adjust the first lateral angle of rotation.

181. The support system of claim 178, wherein the first support piece is separated from the second support piece along the longitudinal axis of the support system.

182. The support system of any of claims 176-181, further comprising a bolster positioned along at least a portion of a first lateral side of the support system to limit lateral migration of the user during sleep.

183. The support system of any of claims 176-182, further comprising a first material layer configured to support the at least one support piece.

184. The support system of claim 183, a second material layer positioned on an opposite side of the at least one support piece and at least partially enveloping the pair of laterally-spaced fluid bladders to retain the pair of laterally-spaced fluid bladders positioned within the support system.

185. The support system of claim 184, wherein the pair of laterally-spaced fluid bladders are removably coupled to at least one of the first material layer and the second material layer such that the sleep surface is adjustable.

186. The support system of any of claims 176-185, wherein the pair of laterally-spaced fluid bladders are inflatable to urge at least a portion of the user's body to rotate.

187. The support system of any of claims 176-186, further comprising a fluid supply in independent fluid communication with the pair of laterally-spaced fluid bladders to supply fluid to each of the first fluid bladder and the second fluid bladder.

188. The support system of any of claims 176-187, wherein the closed air system is configurable in a compact configuration to facilitate storing and transporting the closed air system.

189. The support system of any of claims 176-188, further comprising a computer-implemented control system operatively coupled to the closed air system, the computer-implemented control system comprising:

- a computer having one or more processors; and
- one or more sleep sensors coupled in signal communication with the one or more processors, each of the one or more sleep sensors configured to monitor the user's sleep patterns and transmit one or more signals indicative of the sensed sleep patterns to the one or more processors.

190. The support system of claim 189, based at least in part on the one or more signals received from at least one of the one or more sleep sensors, the control system is configured to inflate or deflate select fluid bladders to reposition the user during sleep to limit the occurrence of a sleep apnea episode.

191. A dynamic support system comprising:

- a person support apparatus comprising a closed air system having at least one support piece configured to form a laterally angled sleep surface having a length defined between a first edge and an opposing second edge spaced from the first edge along a longitudinal axis of the support system, the at least one support piece comprising a pair of laterally-spaced fluid bladders communicatively coupled to each other;

- a computer having one or more processors in operational control communication with the person support apparatus; and

- a plurality of sleep sensors configured to sense user activity during sleep, each sleep sensor of the plurality of sleep sensors in signal communication with the one or more processors and configured to gather data and generate and transmit to the one or more processors signals

indicative of the data gathered, each sleep sensor also configured to receive operation control signals from the one or more processors.

192. The dynamic support system of claim 191, wherein the computer is configured to analyze the data received from each sleep sensor and transmit operational control signals to the support system.

193. The dynamic support system of claim 192, further comprising a fluid supply coupled in communication with the computer, the computer configured to transmit operational control signals to the fluid supply to activate the fluid supply to adjust the sleep surface based on signals generated by the sleep sensors and analyzed within the computer.

194. The dynamic support system of claim 193, wherein the computer is configured to activate the fluid supply to provide air to or remove air from one or more fluid bladders of the pair of laterally-spaced fluid bladders to adjust the sleep surface.

195. The dynamic support system of any of claims 191-194, wherein the computer includes memory to store data.

196. The dynamic support system of any of claims 191-195, wherein user activity includes one or more of the following: the user's body position, a location of the user with respect to the sleep surface, a sleep orientation of the user, the user's vital signs, and the user's sleep state.

197. A method for monitoring sleep activities of a user positioned on a support system including a control system having one or more processors configured to perform such steps, said method comprising:

- activating the control system to monitor the user's sleep activities and patterns as the user begins to sleep; and

- activating the support system to rotate the user at a time during sleep.

198. The method of claim 197, further comprising:

- detecting, by the control system, when the user begins to fall asleep; and

- activating the support system to rotate the user at a time after sleep is detected.

199. The method of claim 198, wherein activating the support system to rotate the user at a time during sleep comprises programming the control system to activate the support system at a time delay.

200. The method of any of claims 197-199, wherein activating the support system to rotate the user at a time during sleep comprises programming the control system to activate the support system at a preset time without relying on monitoring the user's sleep activity.

201. The method of any of claims 197-200, further comprising delaying inter-sleep rotation of the user until the control system detects that the user is in a deep sleep.

202. The method of any of claims 197-201, wherein, when the control system detects that the user is waking, activating the support system by the control system to move the sleep surface to an initial configuration such that the user can exit from the support system.

203. The method of any of claims 197-202, further comprising preventing by the control system activation of the support system if the control system detects the user is sleeping in a lateral decubitus position.

204. The method of any of claims 197-203, further comprising, prior to sleep, inputting to the control system sleep data including one or more of the following: preferred sleeping sides and/or positions, the user's measurements including the user's height, weight, inseam, and/or torso measurements, and preferred lateral angles of rotation and/or preferred longitudinal angles of rotation of one or more support planes defining the sleep surface.

205. The method of claim 204, further comprising activating, using the control system, the support system based at least in part on the user's input data to adjust at least one of a direction and a level of rotation of one or more support planes defining the sleep surface.

206. The method of any of claims 197-205, further comprising collecting and recording by the control system data obtained as the user sleeps to diagnose any undesirable or abnormal sleep activities or conditions.

207. The method of any of claims 197-206, further comprising:

assessing using the control system the user's comfort level during sleep; and comparing a current evaluation with previous evaluations.

208. The method of any of claims 197-207, further comprising mapping the user's body to map body region locations and user activities and movements during sleep.

209. The method of claim 208, further comprising analyzing the data to determine one or more of the following: a location of joints; a preferred surface orientation; and body orientation.

210. The method of claim 208 or claim 209, further comprising calculating a location of one or more support planes based on transition points.

211. The method of claim 210, further comprising assessing using the control system the user's body orientation.

212. The method of any of claims 197-211, further comprising actively monitoring the user's vital signs during sleep using the control system.

213. The method of any of claims 197-212, further comprising, if an adverse event is detected, activating the support system to respond appropriately.

214. A continuous lateral rotation therapy (CLRT) system comprising:  
a support system; and  
a control system operatively coupled to the support system, the control system having one or more processors configured to select an apnea setting for selecting one or more of the following: a number of support planes, dimensions of each support plane, and a desired lateral rotational angle and/or a desired longitudinal rotational angle at which one or more support planes are positioned to define the sleep surface.

215. The CLRT system of claim 214, wherein the control system includes a rotation function to allow constrained rotation at at least one of a torso region and a head region of the sleep surface.

216. The CLRT system of claim 214 or claim 215, wherein the control system includes an apnea mode, wherein blowers are controlled to initiate and maintain rotation of the support planes.

217. The CLRT system of claim 216, wherein, within the apnea mode, the control system is configured to select and define one or more therapy modes.

218. The CLRT system of claim 216 or claim 217, wherein the control system is configured to suggest rotation protocol based at least in part on at least one of sensed data and input data.

219. The CLRT system of any of claims 216-218, wherein the control system is configured to select one or more of the following: a left side slope or a right side slope based on user preference or an alternating lateral rotation, a reverse trend or composite longitudinal angle, a protocol cancel, and a return of the sleep surface to an initial position.

220. The CLRT system of any of claims 214-219, wherein the support system comprises a base support having a plurality of inflatable fluid bladders aligned generally parallel to a longitudinal axis of the support system forming a single support plane having a lateral rotation angle of  $5^{\circ}$  to  $15^{\circ}$  with respect to a base plane of the base support.

221. The CLRT system of claim 220, further comprising one or more supplemental support wedges positioned on the support plane within one or more of a leg region, a torso region, and a head region of the support system.

222. The CLRT system of claim 221, wherein the supplemental support wedge comprises an inflatable fluid bladder.

223. The CLRT system of claim 221 or claim 222, wherein the supplemental support wedge is positioned at the head region of support system and forms a supplemental support plane having a first lateral rotation angle with respect to a base plane of the supplemental support wedge such that a supplemental support plane is positioned at a total lateral rotational angle with respect to the base plane of the base support.

224. The CLRT system of any of claims 220-223, further comprising a laterally positioned side constraint to limit inflation of individual fluid bladders forming the base support.

225. The CLRT system of any of claims 220-224, further comprising a plurality of fixed length bands positioned with respect to individual fluid bladders to limit inflation of the individual fluid bladders.

226. A posture garment configured to be worn by a user to apply an appropriate force on the user to urge the user's head to rotate and open the user's upper respiratory tract to limit the occurrence of sleep apnea, the posture garment comprising one or more select areas located on at least one of a front portion of the posture garment and a back portion of the posture garment including a material having a different elasticity than other areas of the posture garment to facilitate positioning the user in a desired direction to open the upper respiratory airway.

227. The posture garment of claim 226, wherein the one or more select areas include a plurality of sections each made of a material having a different elasticity that work cooperatively to position the user's body in the desired position.

228. A method, comprising the steps of:  
receiving an input indicative of an adverse event risk score;  
determining if a sleep apnea event is likely based on the input; and  
if a sleep apnea event is likely, generating an intervention.

229. The method of claim 228, wherein the intervention includes alerting a caregiver that the person is at risk for sleep apnea.

230. The method of claim 228 or claim 229, wherein the intervention includes activating a therapy.

231. The method of any of claims 228-230, wherein the intervention includes causing a person support structure supporting the person to perform a function.

232. The method of claim 231, wherein the person support structure rotates a person about an axis extending along the length of the person support structure.

233. The method of any of claims 228-232, wherein the input is received from an electronic medical record system.
234. The method of any of claims 228-233, wherein the intervention is canceled if the person is in a predetermined posture.
235. A method, comprising the steps of:  
receiving a plurality of inputs indicative of a characteristic of a person;  
determining if an adverse event is likely based on a trend indicated by the plurality of inputs; and  
if a sleep apnea event is likely, generating an intervention.
236. The method of claim 235, wherein the characteristic includes at least one of a respiration rate, a respiration amplitude, a heart rate, a sleep state, and a posture of a person.
237. The method of claim 235 or claim 236, wherein the intervention includes activating a therapy.
238. The method of claim 237, wherein the therapy includes rotational therapy.
239. The method of any of claims 235-238, wherein the intervention is initiated based on the person's sleep state.
240. The method of any of claims 235-239, wherein the intervention causes a person support structure to perform a function.
241. The method of any of claims 235-240, wherein the intervention causes a person support structure to change its configuration.
242. The method of claim 241, wherein the person support structure is configured to elevate the upper body of the person.
243. The method of claim 241 or claim 242, wherein the person support structure is configured to laterally rotate the head of the person.

244. A person support apparatus to support a person in at least a horizontal position, the person support apparatus comprising:

a plurality of support sections arranged along a length of the person support apparatus, each of the support sections having a support surface to support a body portion of the person and an inflatable portion supporting the support surface, the inflatable portion of the support section selectively inflatable and deflatable to position the support surface of the support section in a tilt position in which the support surface is angled at a maximum lateral tilt angle and position the support surface in a flat position in which the support surface is angled at a substantially flat angle, wherein the support surfaces of at least two of the support sections have different maximum lateral tilt angles.

245. The person support apparatus of claim 244, wherein the plurality of support sections comprises a head section to support the person's head, a seat section to support the person's torso, and a foot section to support the person's feet, the maximum lateral tilt angle of the support surface of the head section is greater than the maximum lateral tilt angle of the support surface of the seat section and the maximum lateral tilt angle of the seat section is greater than the maximum lateral tilt angle of the foot section.

246. The person support apparatus of claim 244 or claim 245, wherein the inflatable portion of each of the support sections is inflated to position the support surface in the tilt position and deflated to position the support surface in the flat position.

247. The person support apparatus of any of claims 244-246, wherein the inflatable portion of each of the support sections is deflated to position the support surface in the tilt position and inflated to position the support surface in the flat position.

248. The person support apparatus of any of claims 244-247, wherein each of the support sections comprises a non-inflatable support member in cooperation with the inflatable portion to selectively position the support surface of the support section in the tilt position and the flat position.

249. The person support apparatus of claim 248, wherein the inflatable portion is supported by the non-inflatable support member.

250. The person support apparatus of claim 248 or claim 249, wherein the inflatable portion supports the non-inflatable support member.

251. The person support apparatus of any of claims 244-250, wherein the inflatable portion comprises a bellows-shaped bladder.

252. The person support apparatus of claim 251, wherein the bellows-shaped bladder is inflatable to position the support surface of the support section at the maximum lateral tilt angle by rotating the support surface about a longitudinal axis of the person support apparatus located adjacent a first side of the person support apparatus.

253. The person support apparatus of claim 252, comprising a second bellows-shaped bladder supported by the first bellows shaped bladder and inflatable to position the support surface of the support section at the maximum lateral tilt angle by rotating the support surface about a second longitudinal axis of the person support apparatus located adjacent a second side of the person support apparatus, wherein the second side of the person support apparatus is laterally spaced from the first side.

254. The person support apparatus of claim 252 or claim 253, comprising a plurality of baffles in an interior region of the bellows-shaped bladder, wherein each of the baffles has a different length.

255. The person support apparatus of any of claims 244-254, wherein the support section comprises a side member positioned adjacent a vertex of the maximum lateral tilt angle of the support surface.

256. The person support apparatus of claim 255, wherein the side member extends along the length of the person support apparatus and the side member has a length that is less than the length of the person support apparatus.

257. The person support apparatus of any of claims 244-256, comprising a cover sized to enclose the support sections in an interior region, wherein the cover comprises expandable sections corresponding to the support sections to accommodate the support sections when the

support surface of each of the support sections is in the tilt position and when the support surface of each of the support sections is in the flat position.

258. The person support apparatus of any of claims 244-257, wherein the inflatable portion of each of the support sections comprises a multiple-chamber bladder assembly, and wherein each of the bladders in the multiple-chamber bladder assembly is inflatable to a different height.

259. The person support apparatus of claim 258, wherein each of the bladders of the multiple-chamber bladder assembly is substantially log shaped and the bladders are in fluid communication with each other.

260. The person support apparatus of any of claims 244-259, wherein each support section comprises a sensor to measure the lateral tilt angle of the support surface of the support section, wherein the sensor is coupled to the support section.

261. The person support apparatus of claim 260, wherein the sensor is enclosed within an interior region of the support section.

262. The person support apparatus of any of claims 244-261, wherein the person support apparatus is in communication with an air control system and a person weighing system to determine the weight of a person positioned on the person support apparatus, and the air control system adjusts the amount of air pressure supplied to the inflatable portion of each of the support sections to achieve the maximum tilt angle of the support surface of the support section in response to a weight detected by the person weighing system.

263. The person support apparatus of any of claims 244-262, wherein the inflatable portion of each of the support sections comprises a three-dimensional matrix defined by a plurality of horizontally aligned columns of vertically stacked inflatable bladders.

264. The person support apparatus of claim 263, wherein each of the inflatable bladders is configured to assume a log-like shape when inflated.

265. The person support apparatus of claim 263 or claim 264, wherein each of the inflatable bladders is configured to assume a sphere-like shape when inflated.

266. The person support apparatus of any of claims 244-265, wherein the inflatable portion of each of the support sections comprises a two-dimensional matrix comprising a plurality of rows and columns of horizontally aligned inflatable bladders, wherein the maximum height of the bladders is adjustable to achieve the maximum tilt angle of the support section.

267. The person support apparatus of any of claims 244-266, wherein the inflatable portion comprises a pair of laterally-spaced inflatable bladders and a non-inflatable member supported by the pair of laterally-spaced inflatable bladders, wherein the non-inflatable member supports the support surface and the support surface assumes the tilt position when both of the inflatable bladders are at least partially inflated and one of the inflatable bladders is inflated to a different height than the other inflatable bladder.

268. The person support apparatus of any of claims 244-267, wherein the each of the support sections comprises a wedge-shaped non-inflatable base and the inflatable portion is supported by the wedge-shaped non-inflatable base.

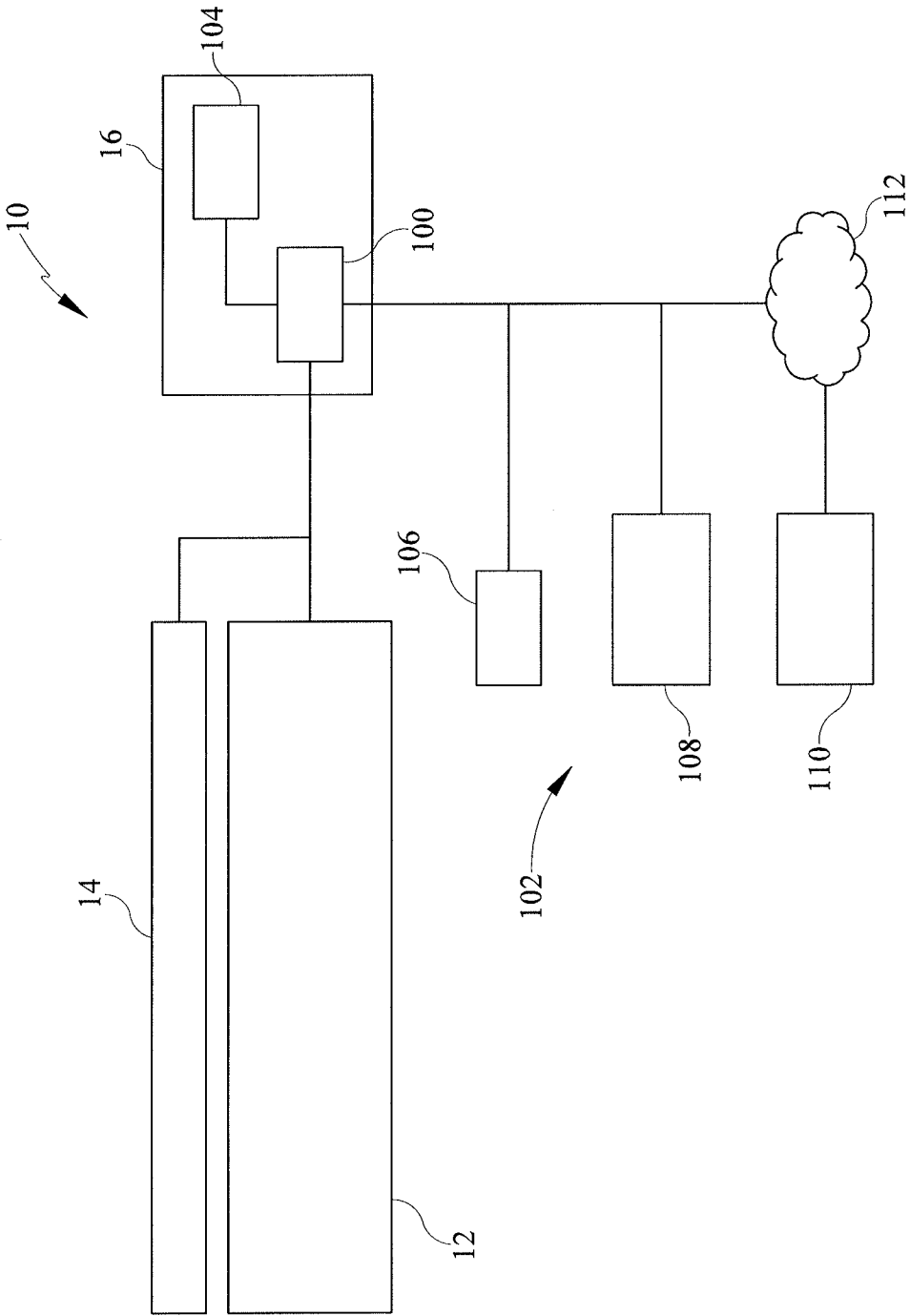
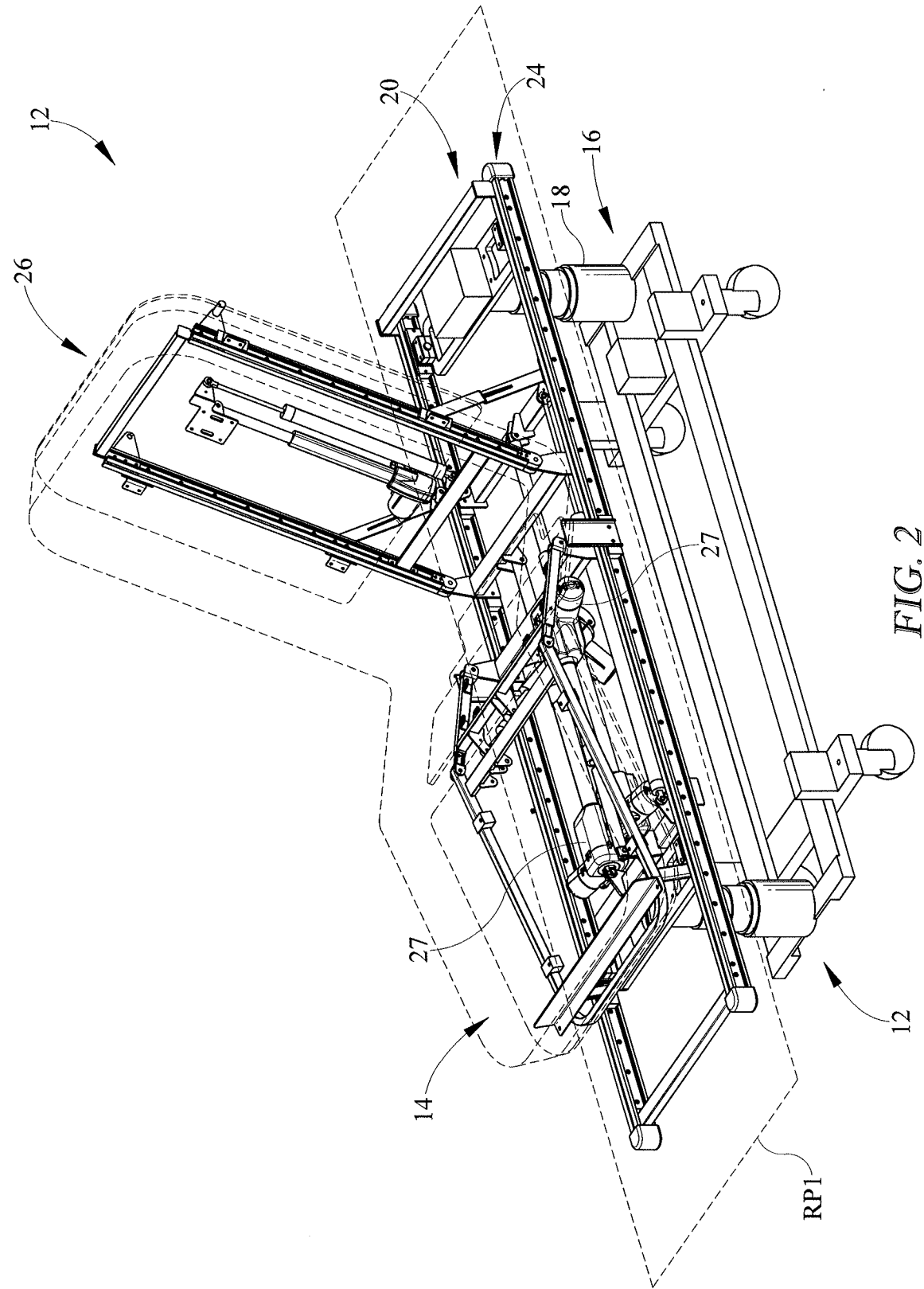
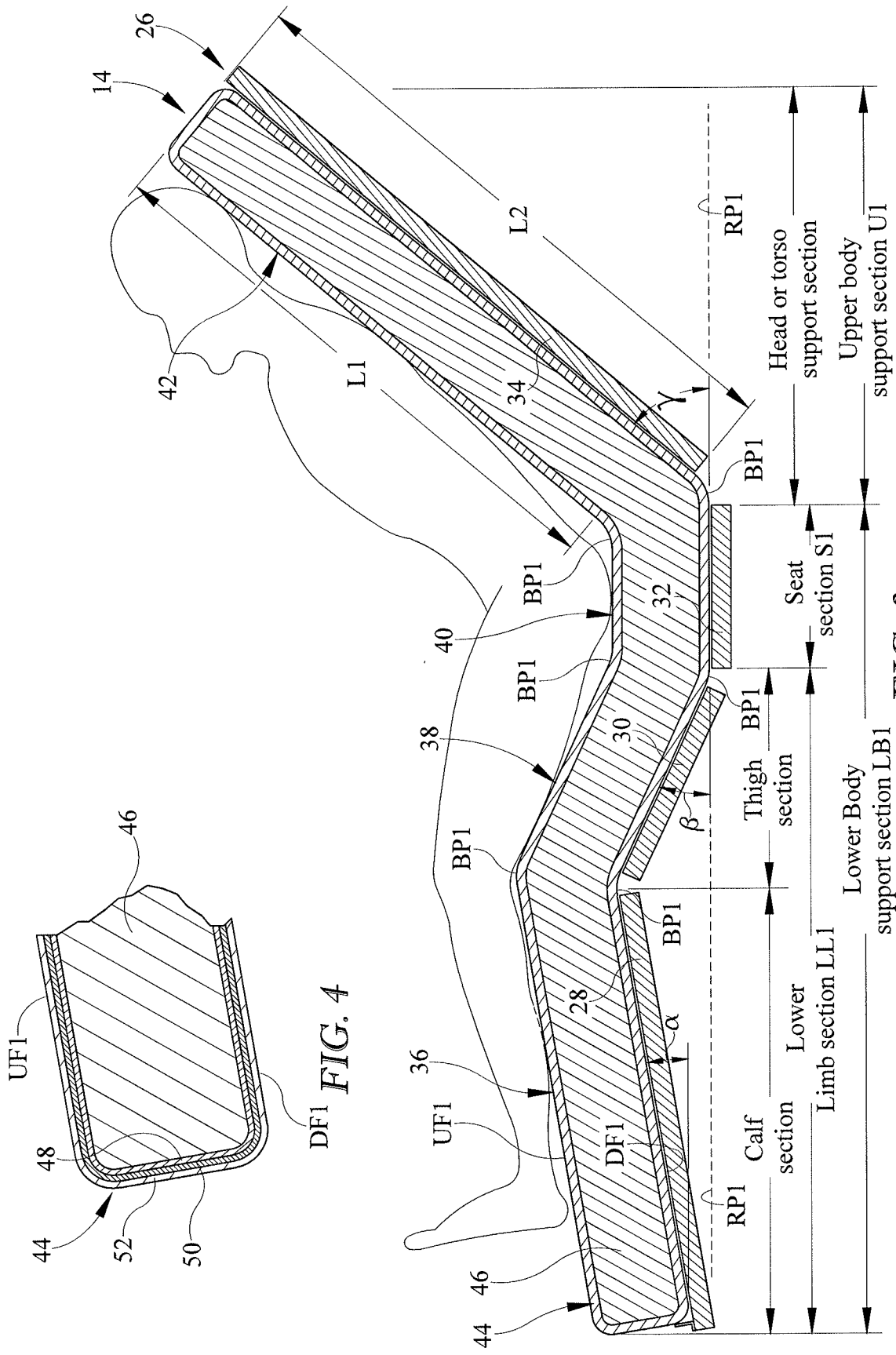


FIG. 1





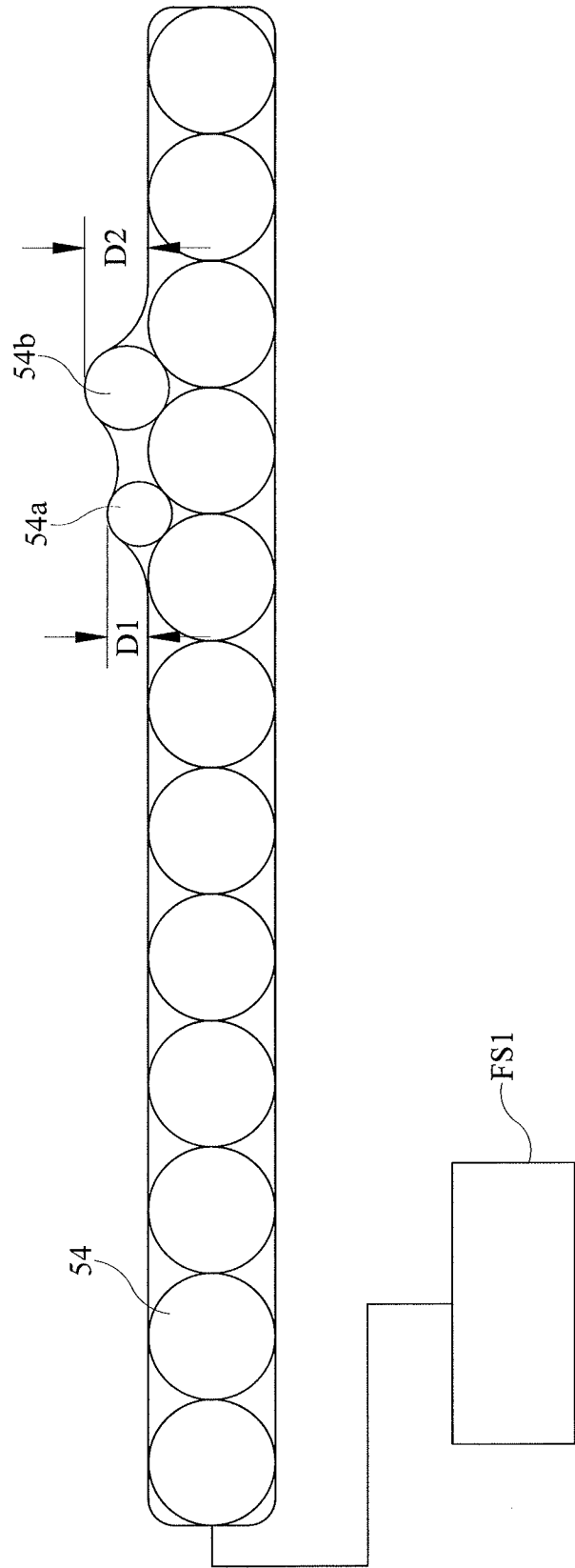
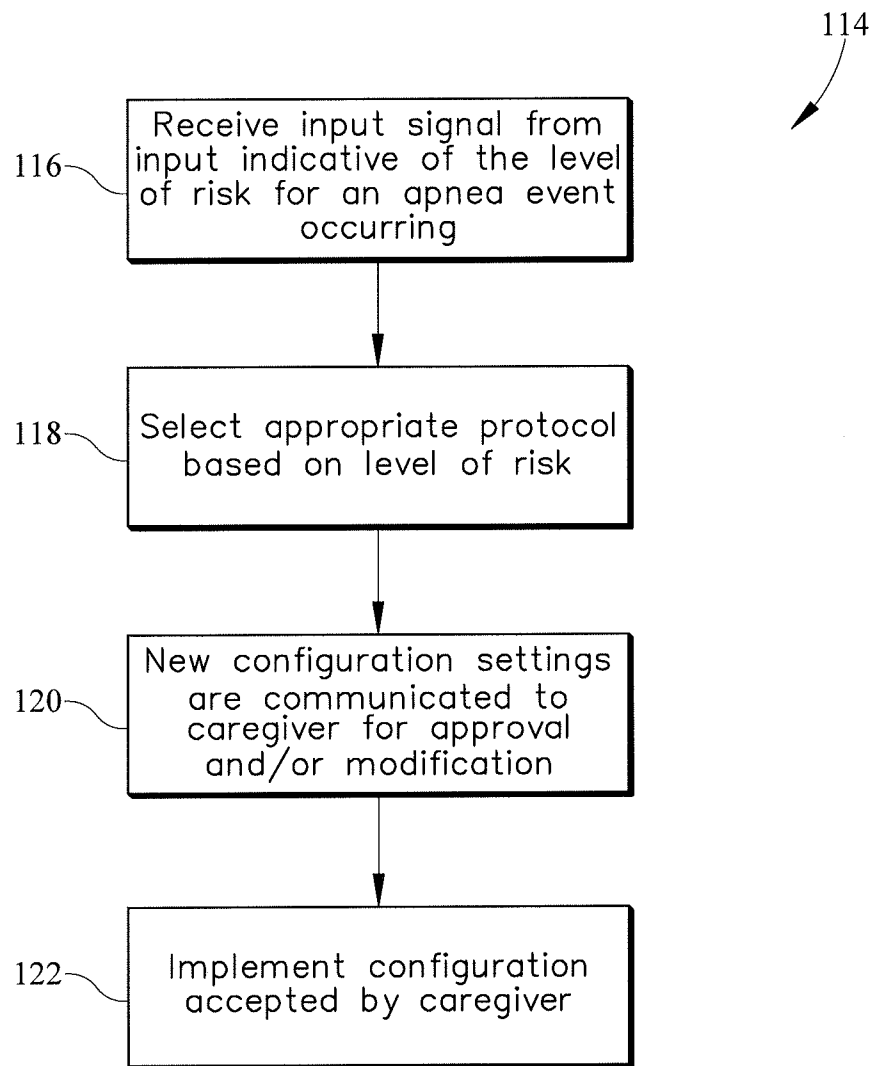


FIG. 5

*FIG. 6*

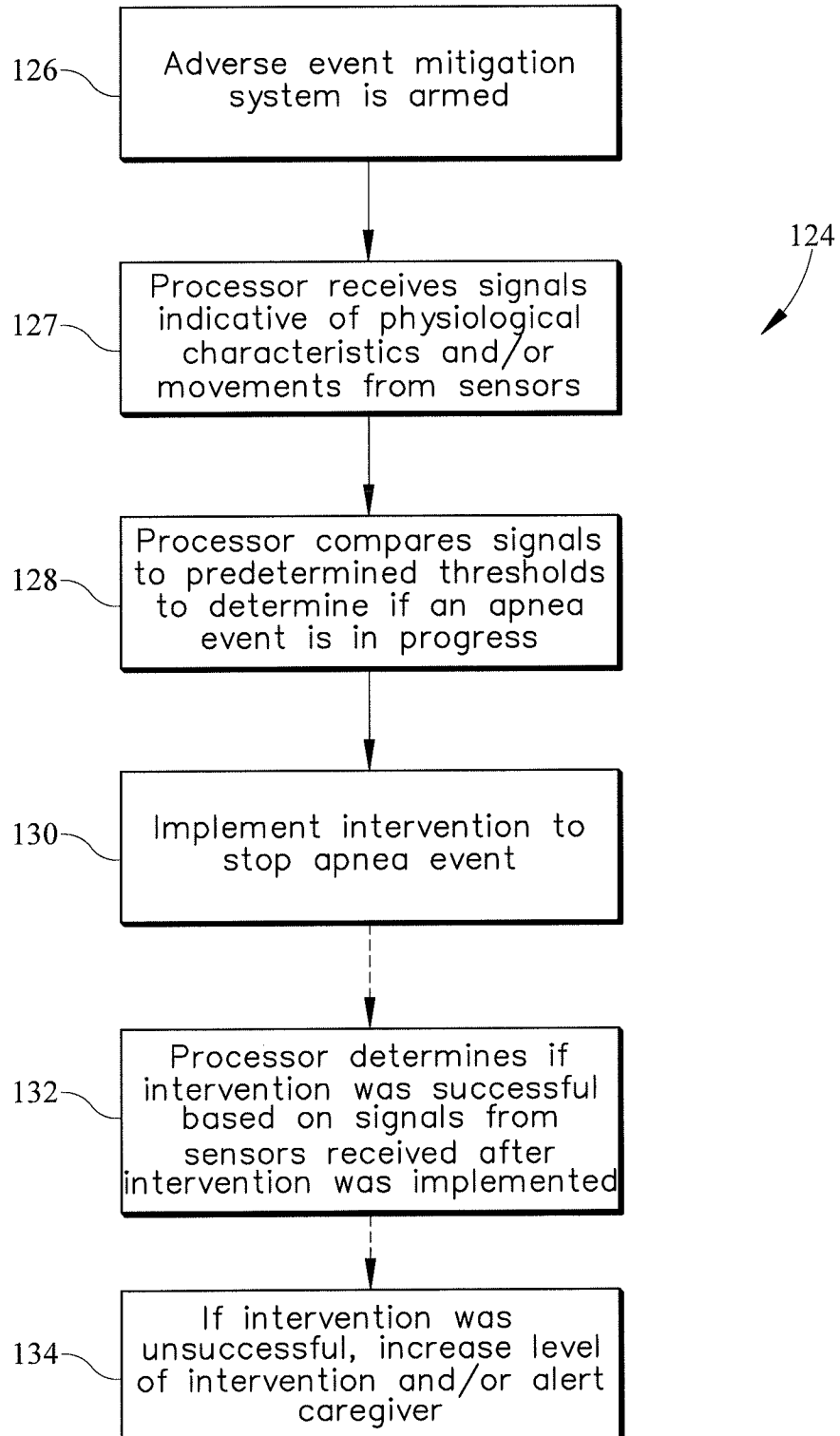
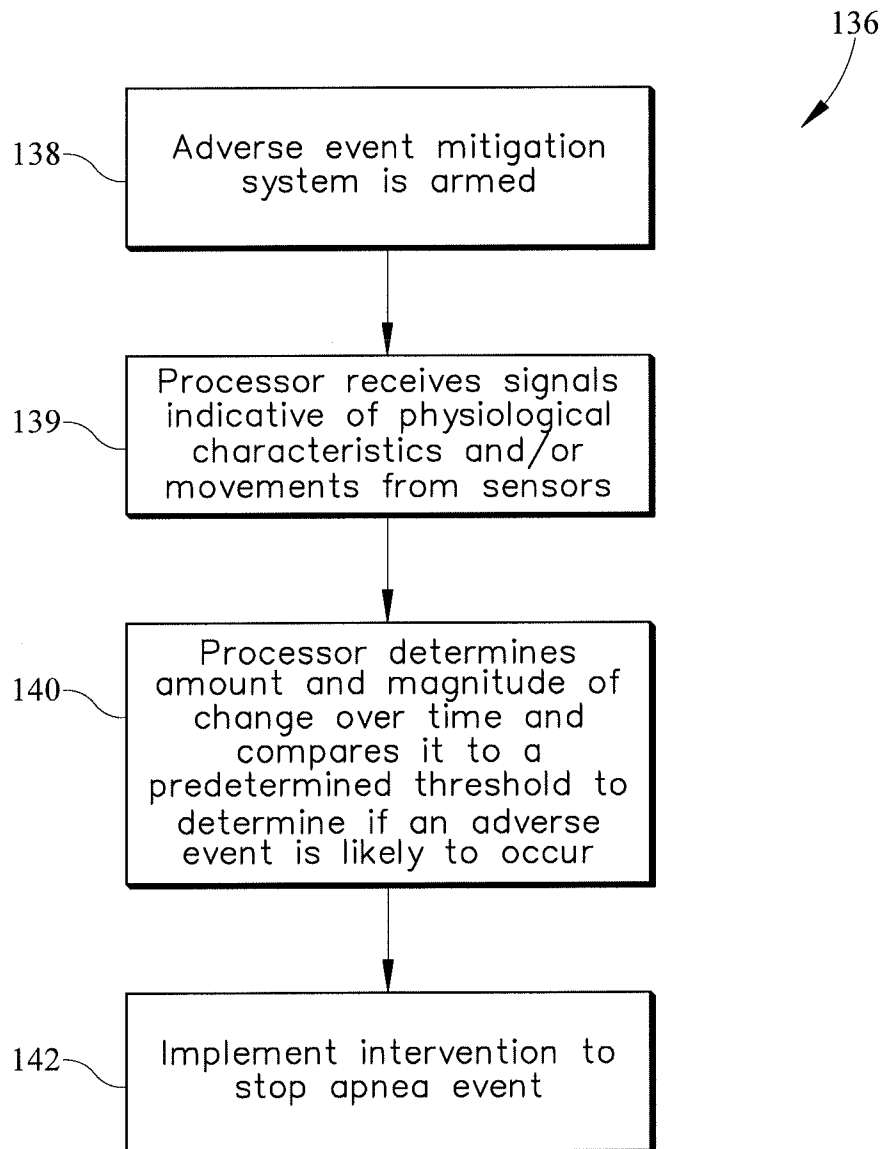


FIG. 7

*FIG. 8*

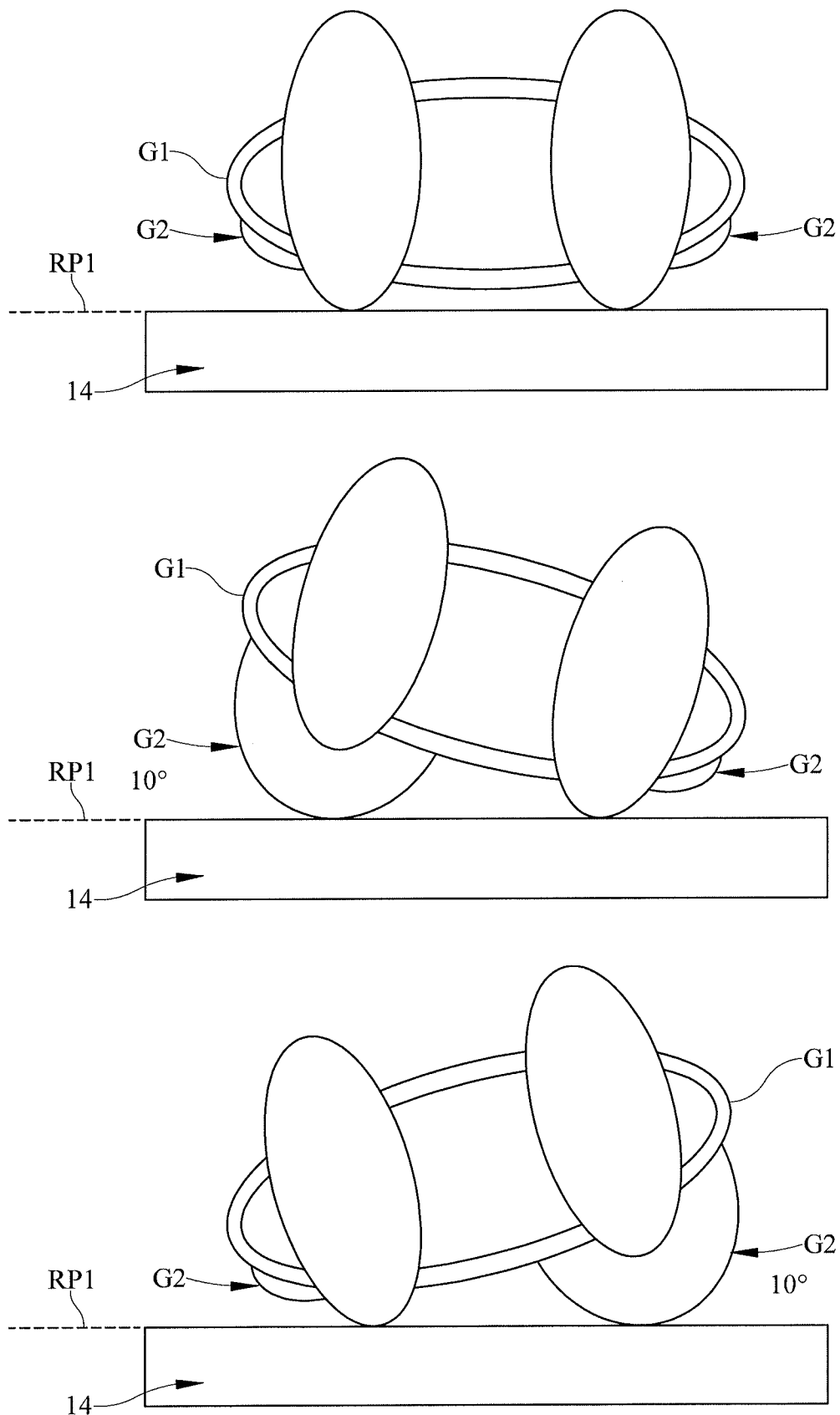
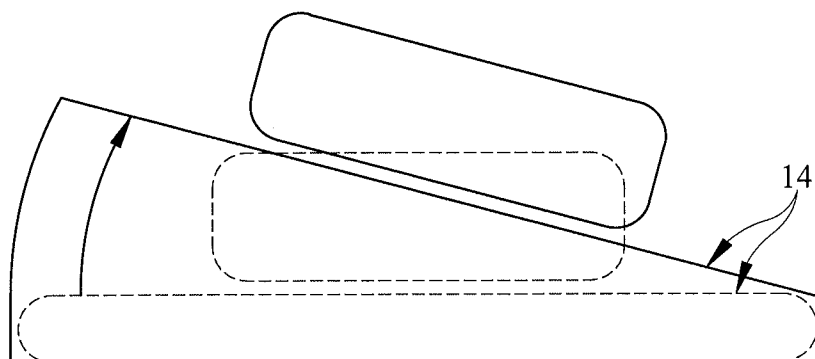
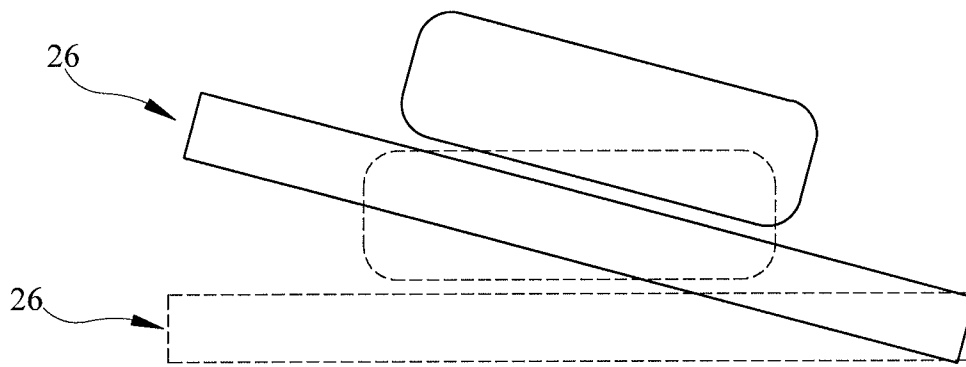
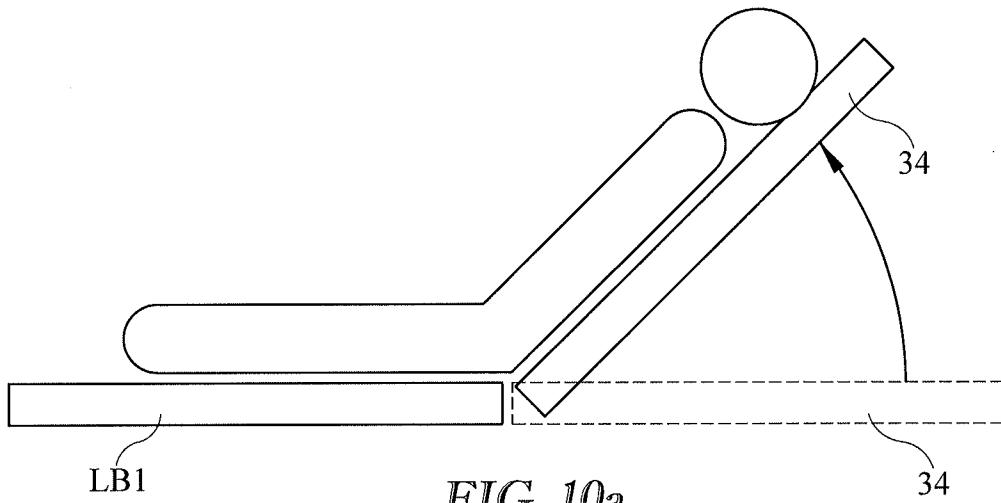


FIG. 9



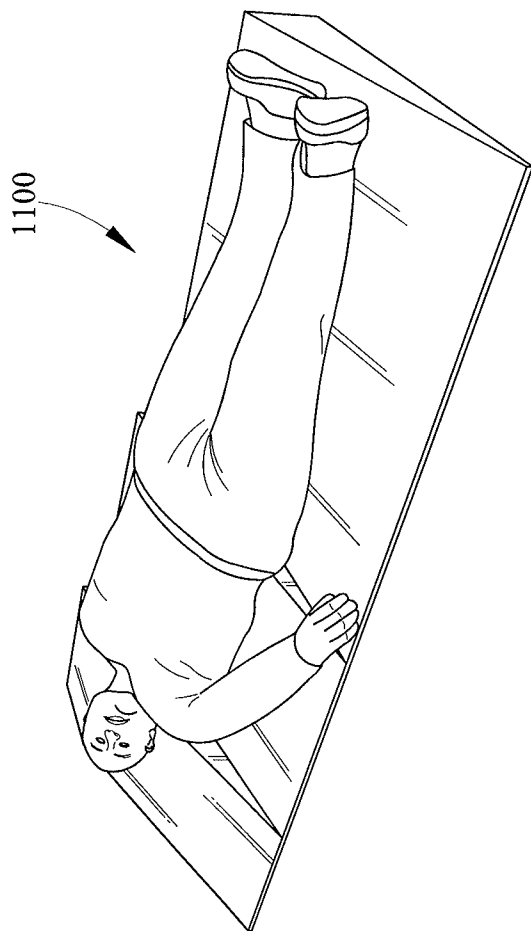


FIG. 11

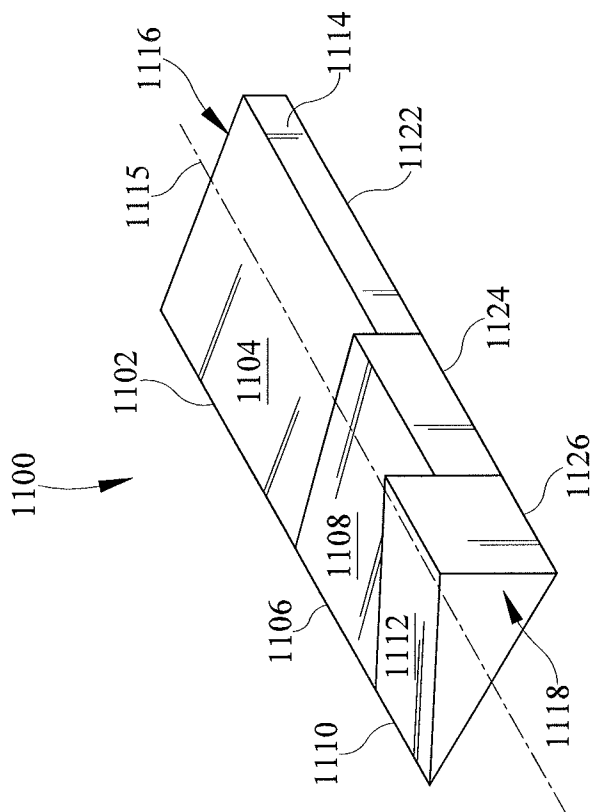


FIG. 12

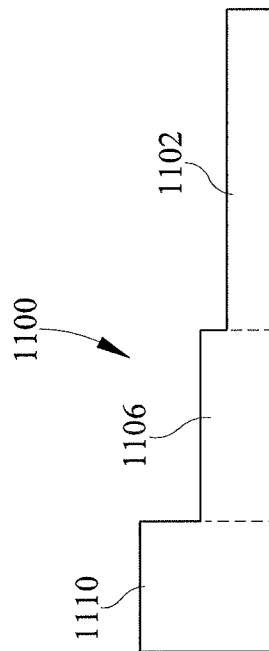


FIG. 13

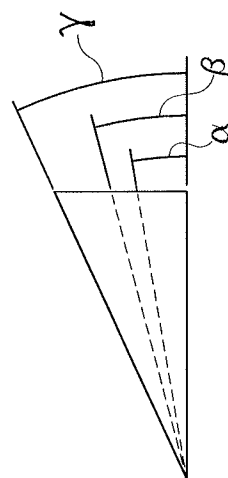
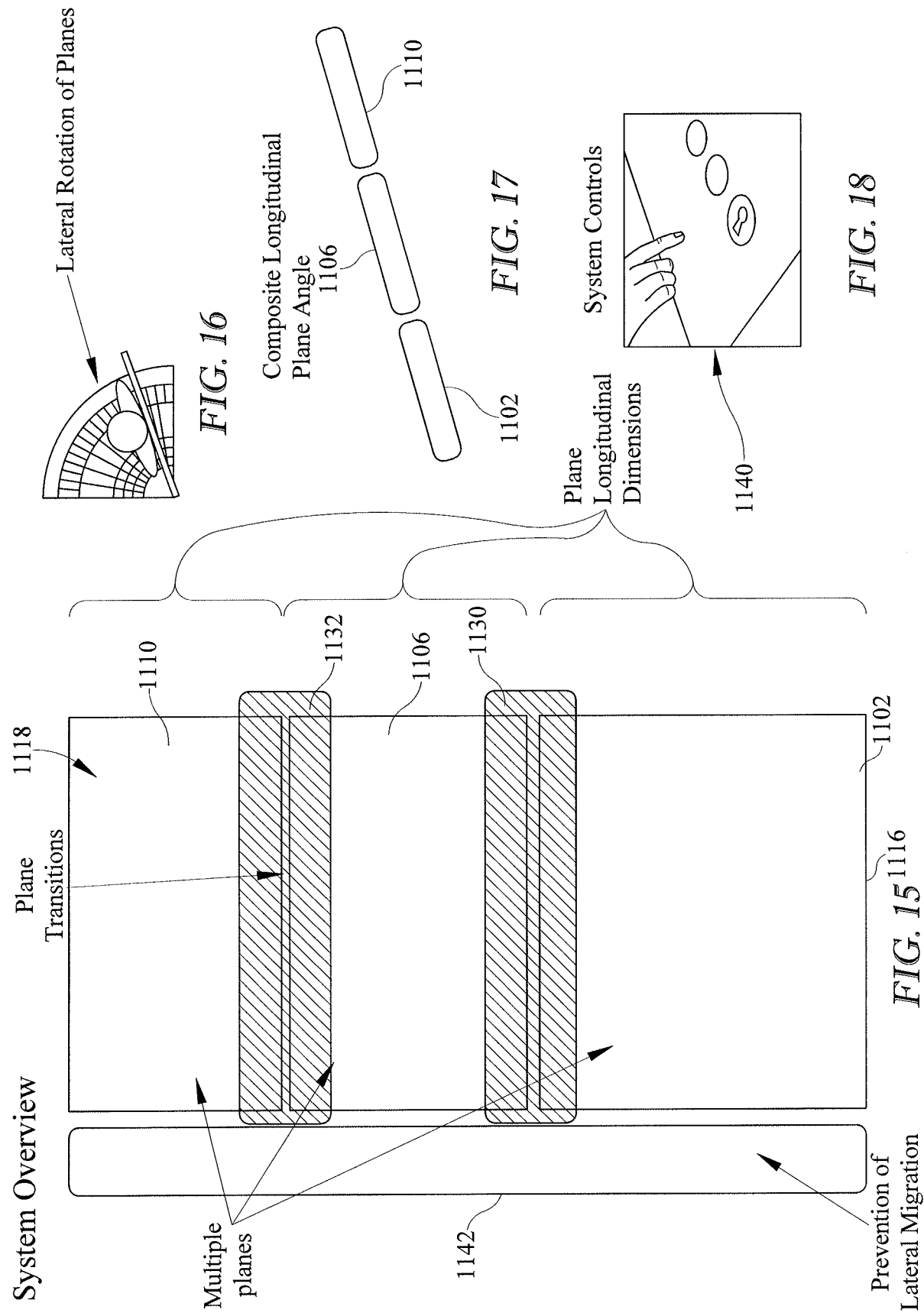


FIG. 14



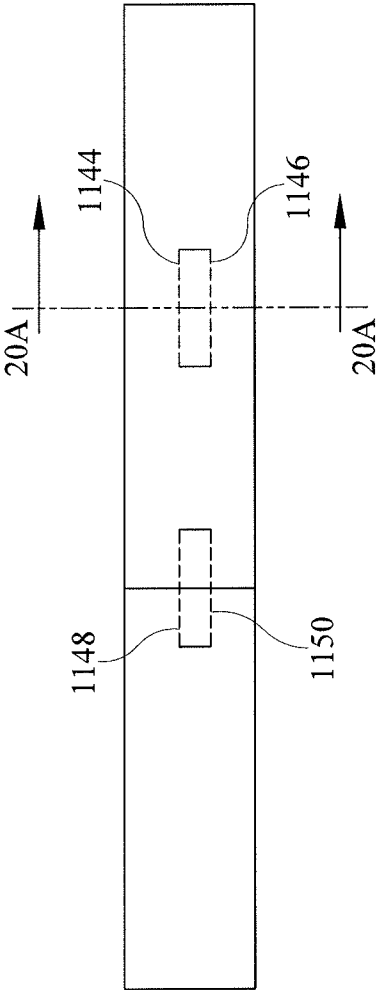


FIG. 19

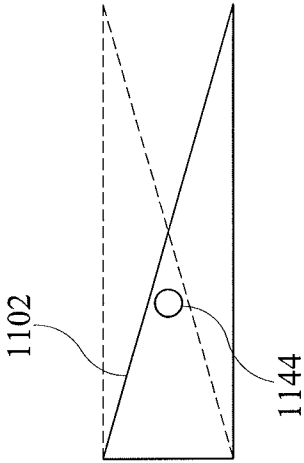


FIG. 20A

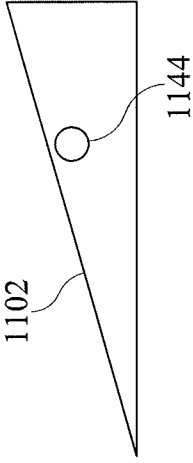


FIG. 20B

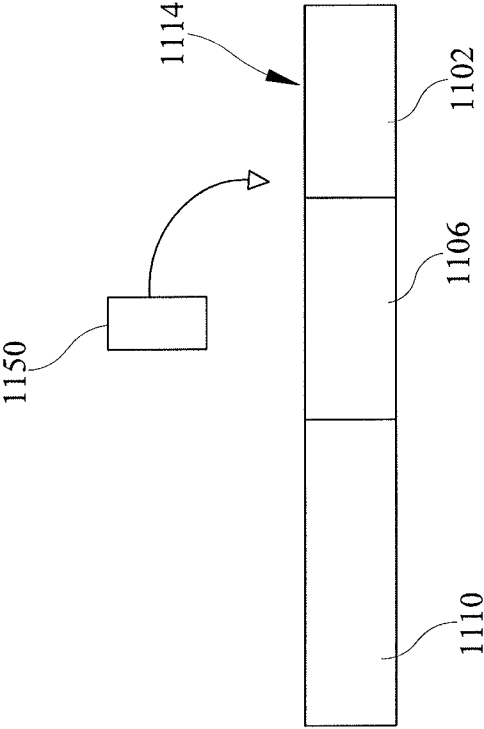


FIG. 21

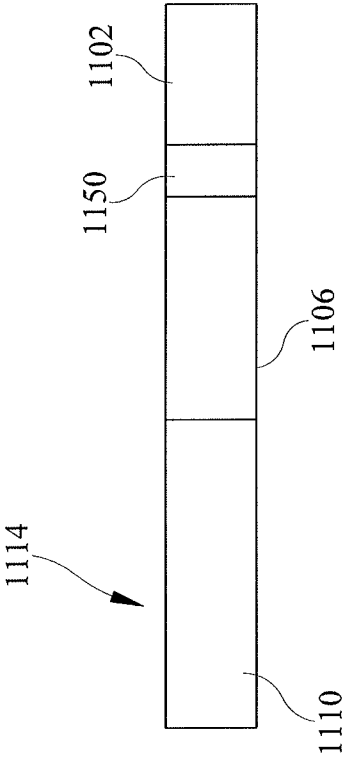


FIG. 22

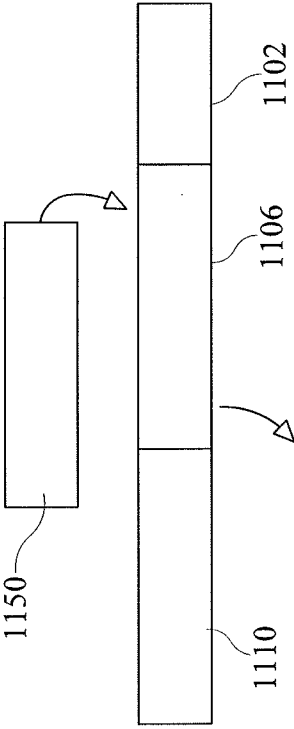


FIG. 23

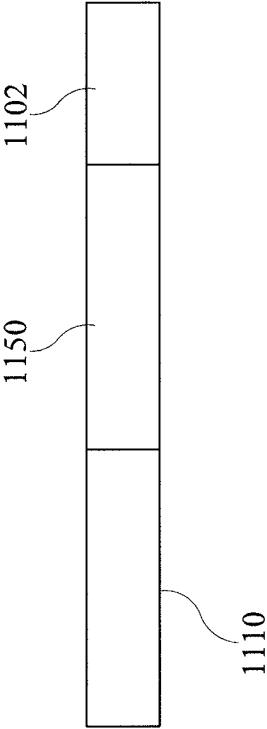


FIG. 24

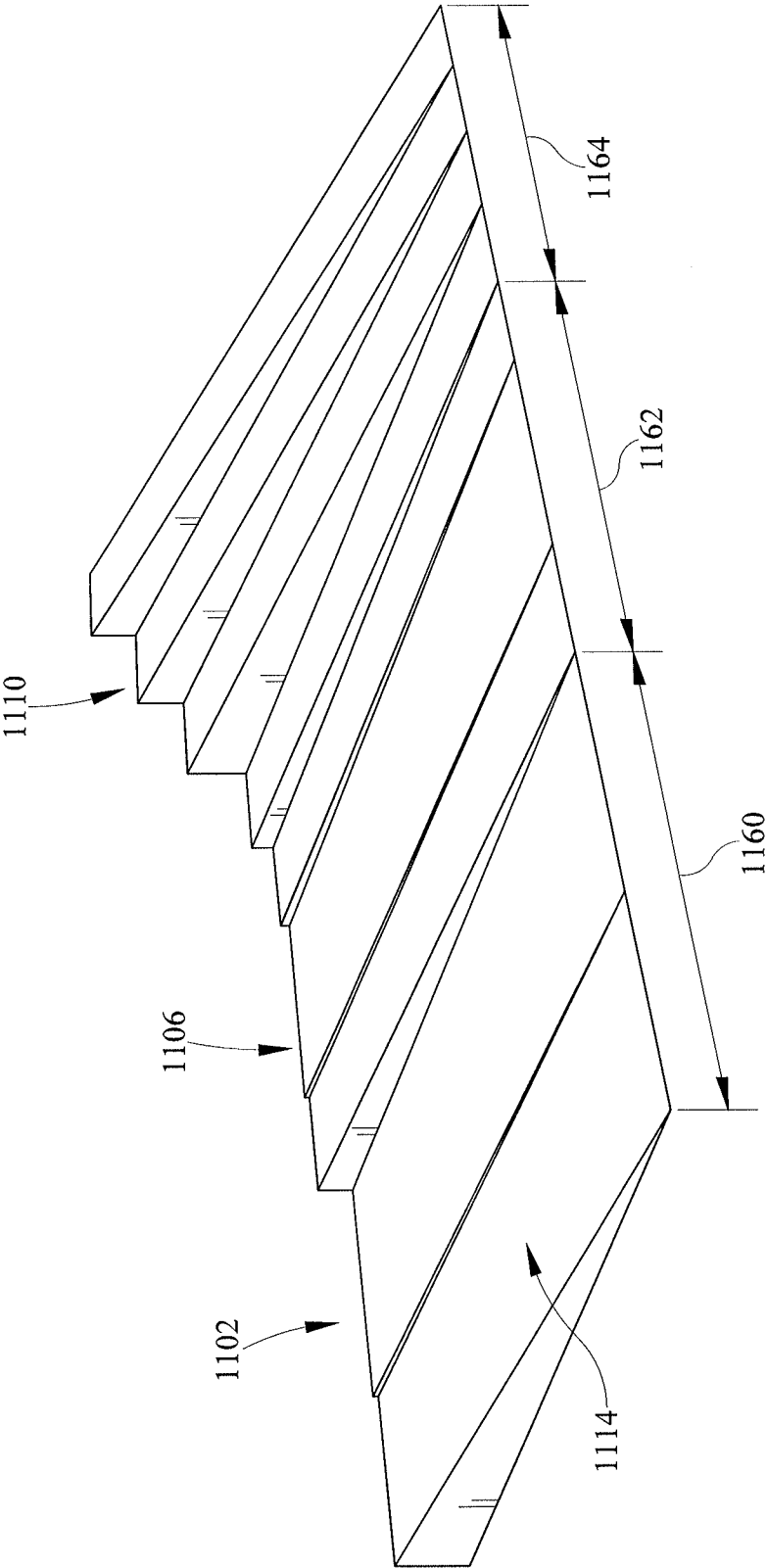


FIG. 25

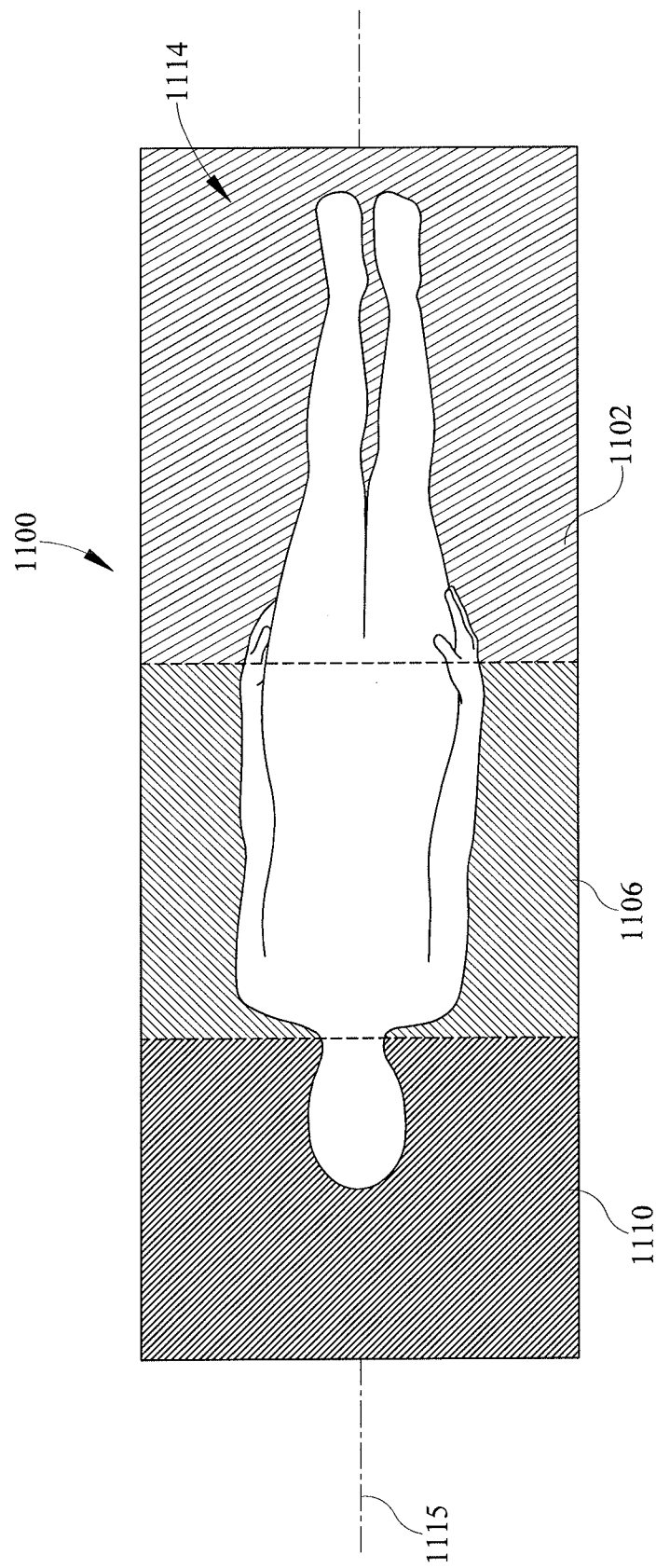


FIG. 26



FIG. 27

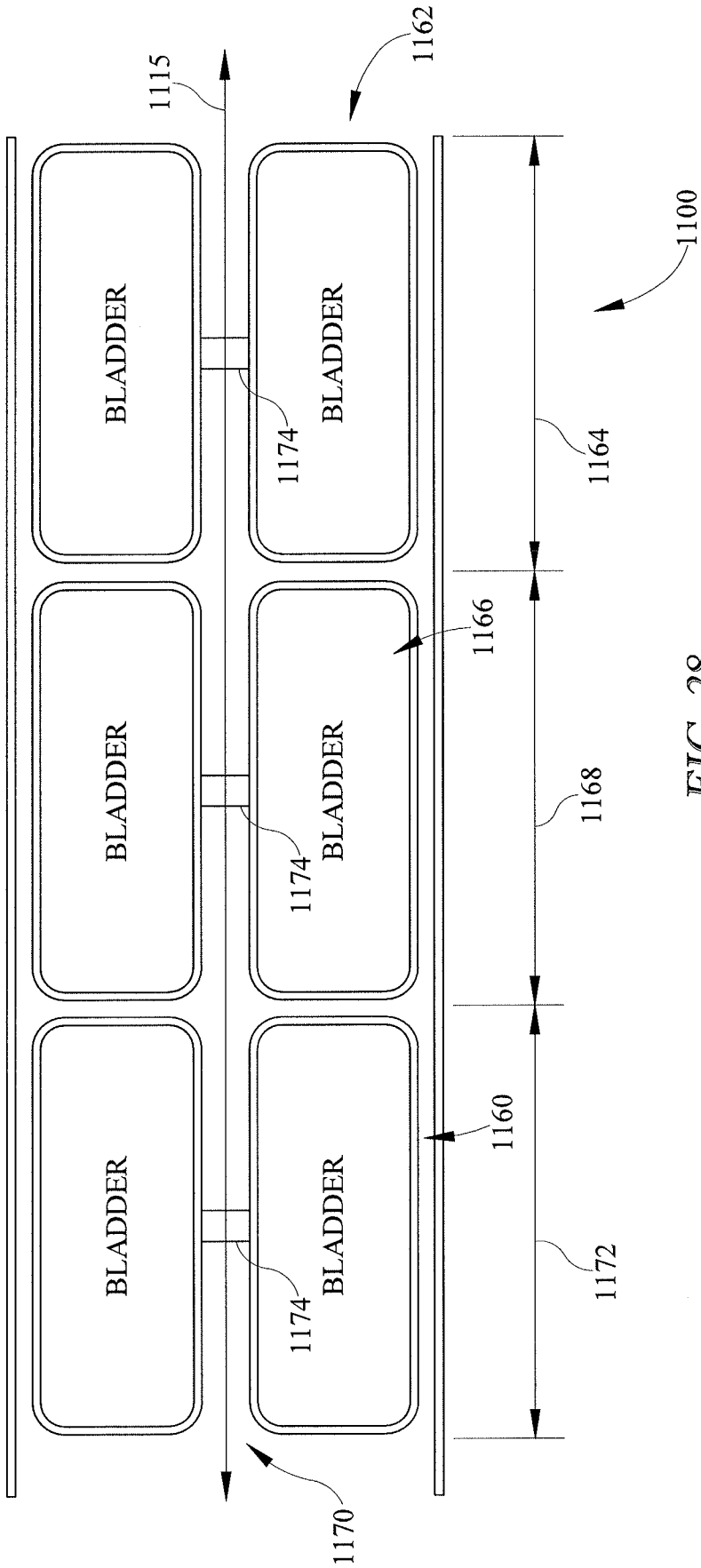


FIG. 28

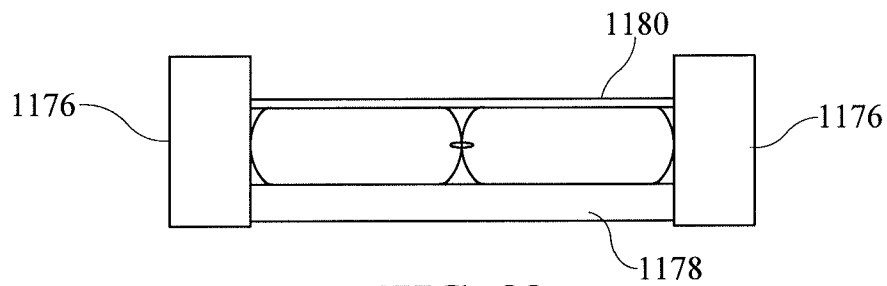


FIG. 29

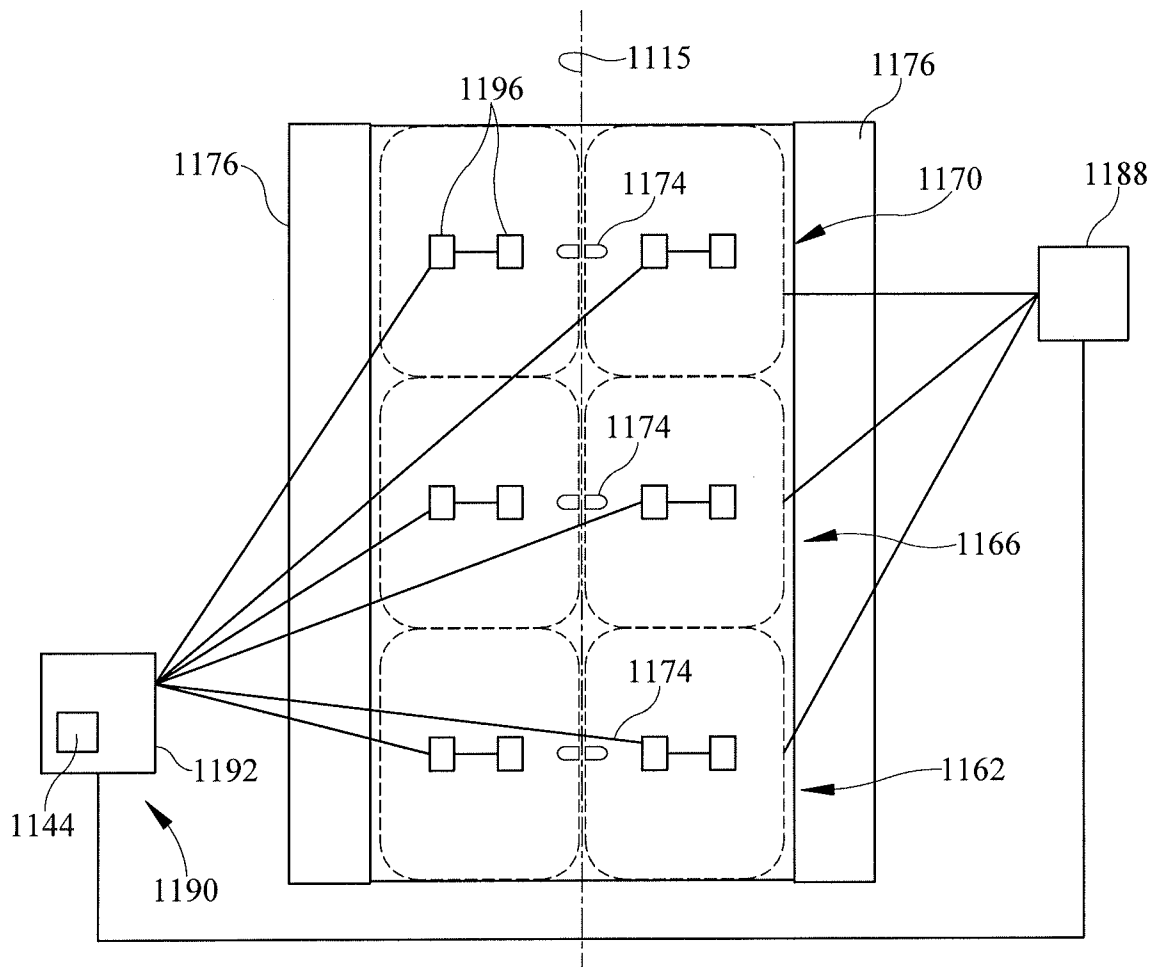


FIG. 30

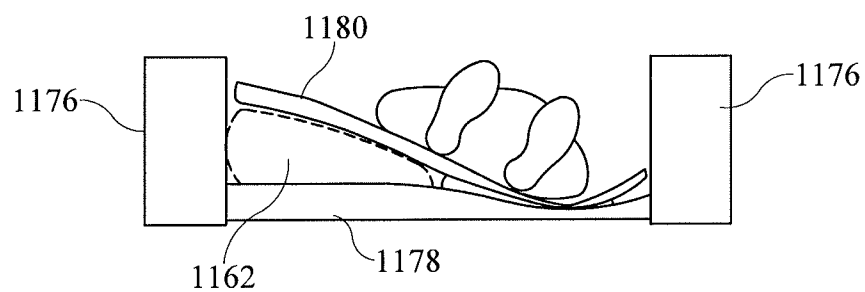


FIG. 31



*FIG. 32*

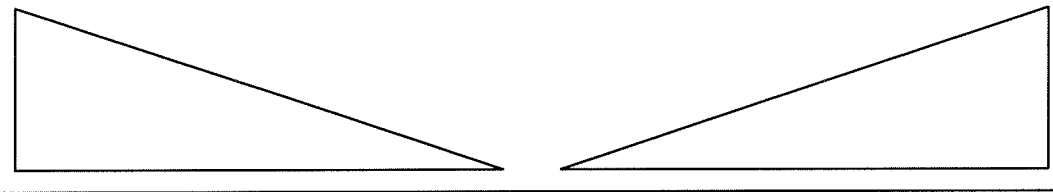


*FIG. 33*

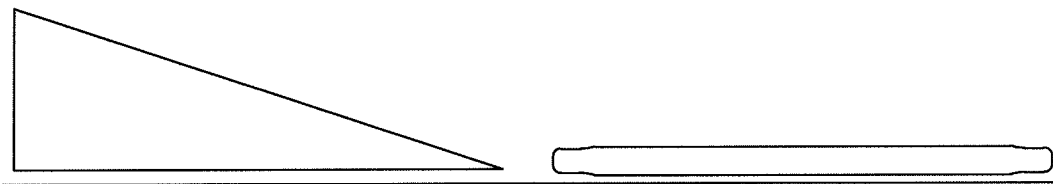
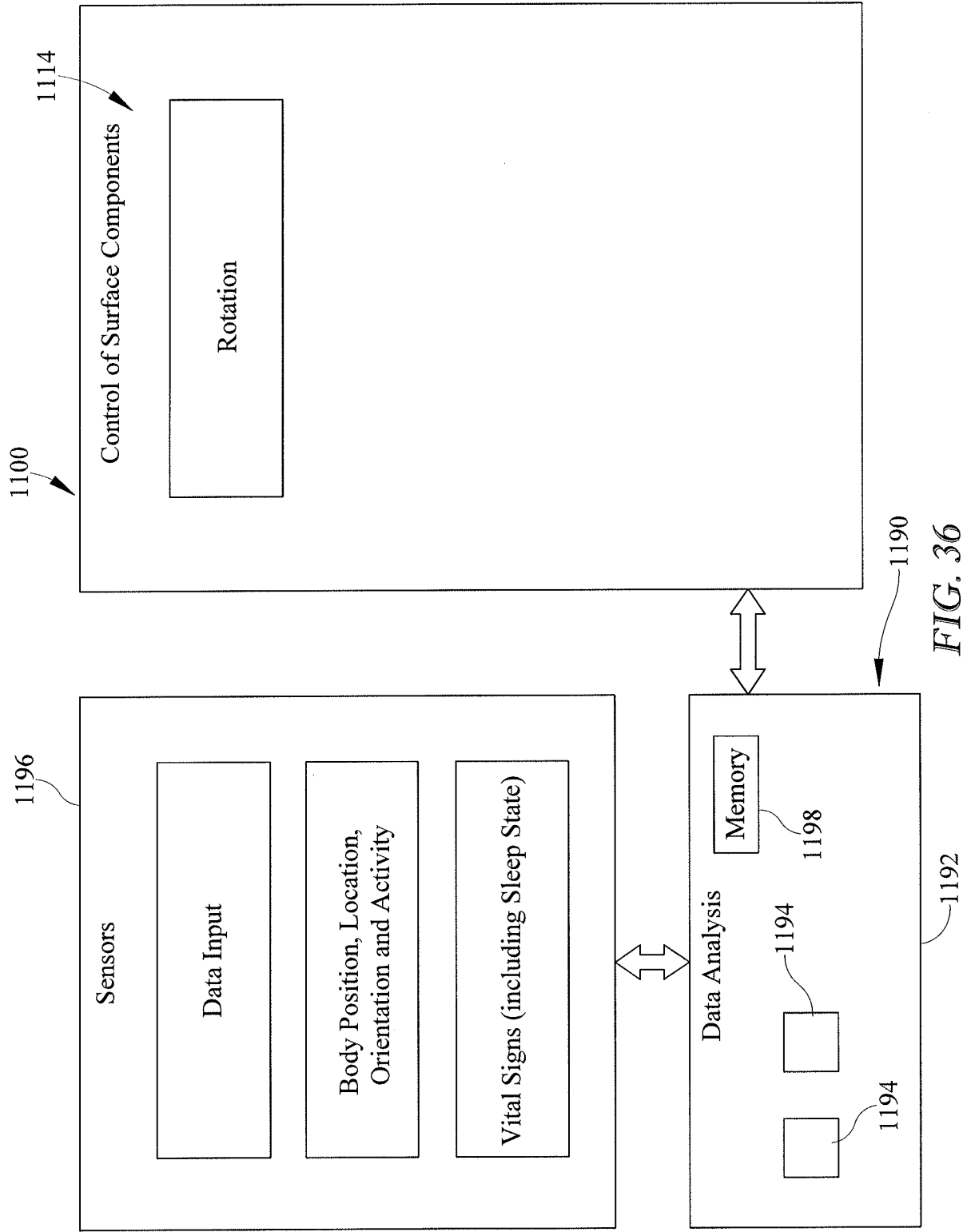


*FIG. 34*



*FIG. 35*



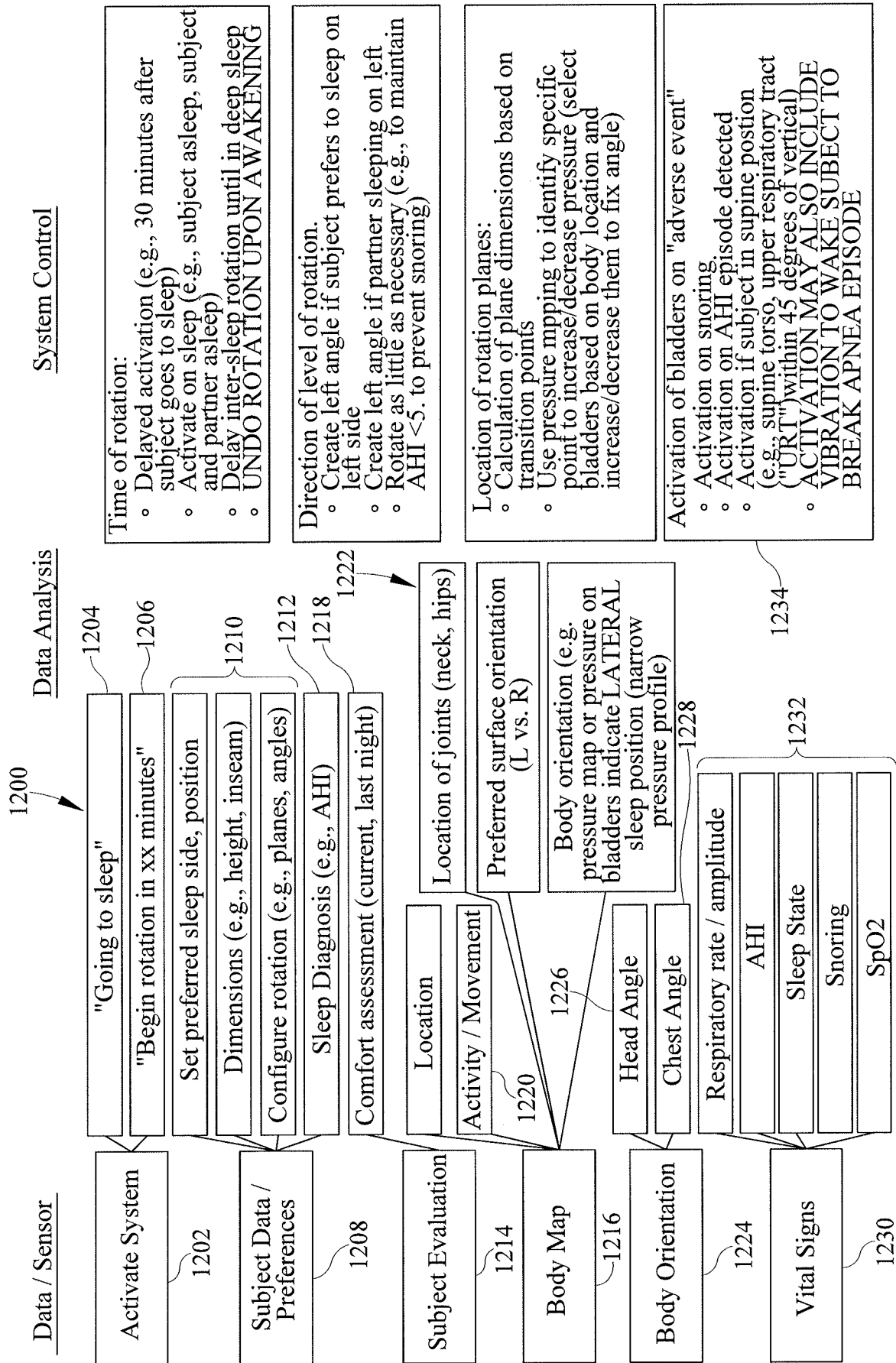


FIG. 37

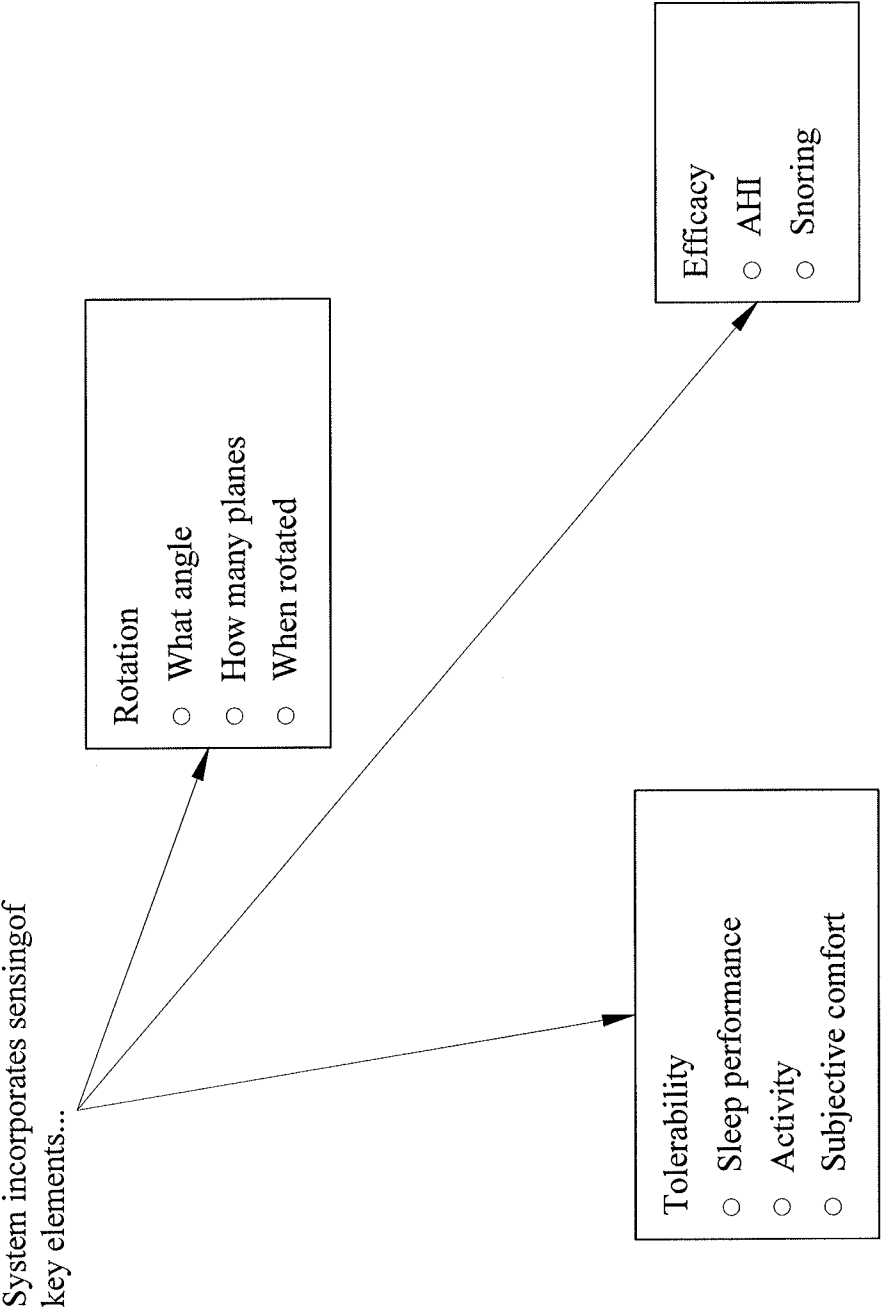


FIG. 38

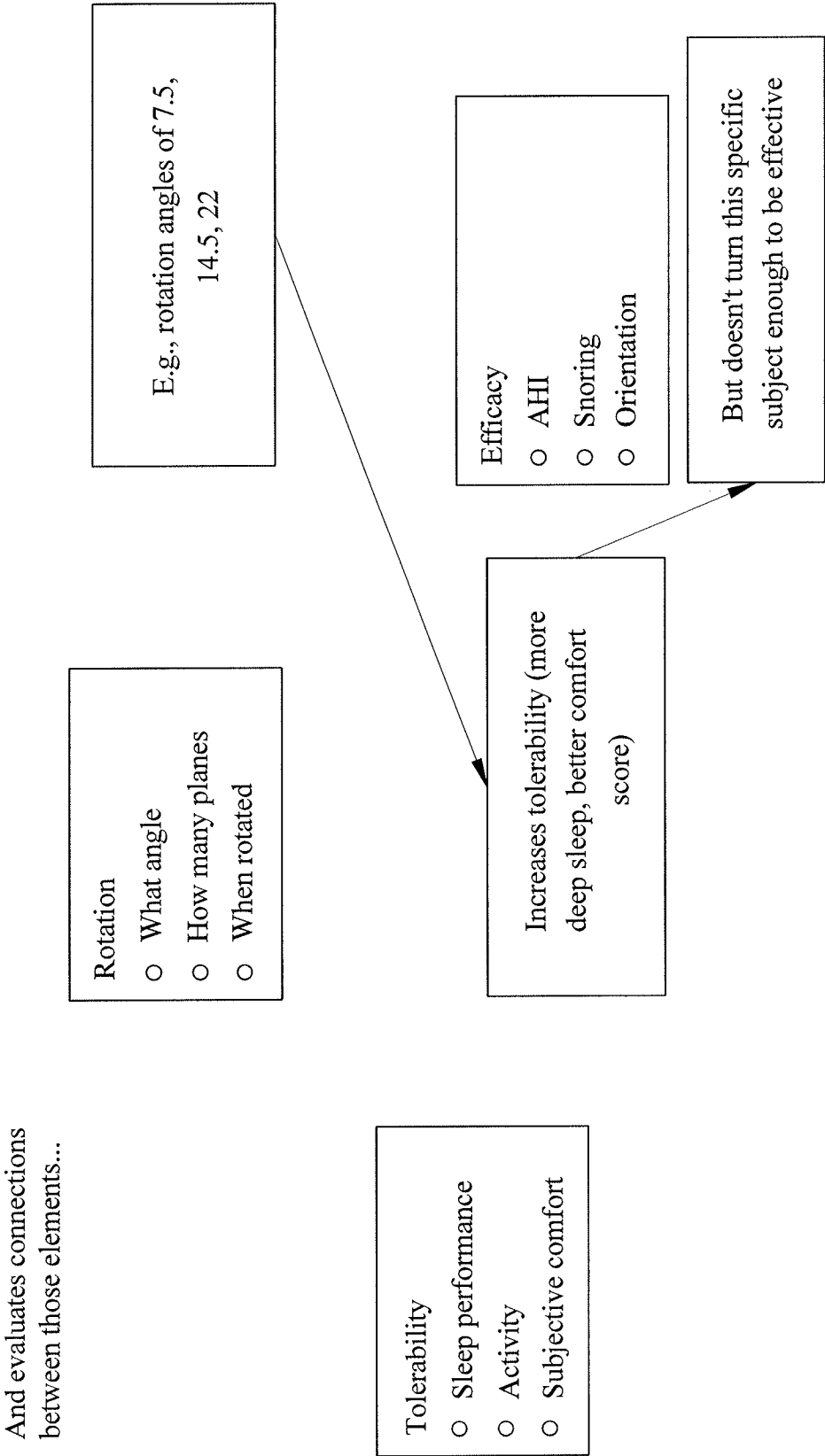


FIG. 39

Until the balance between the elements is optimized

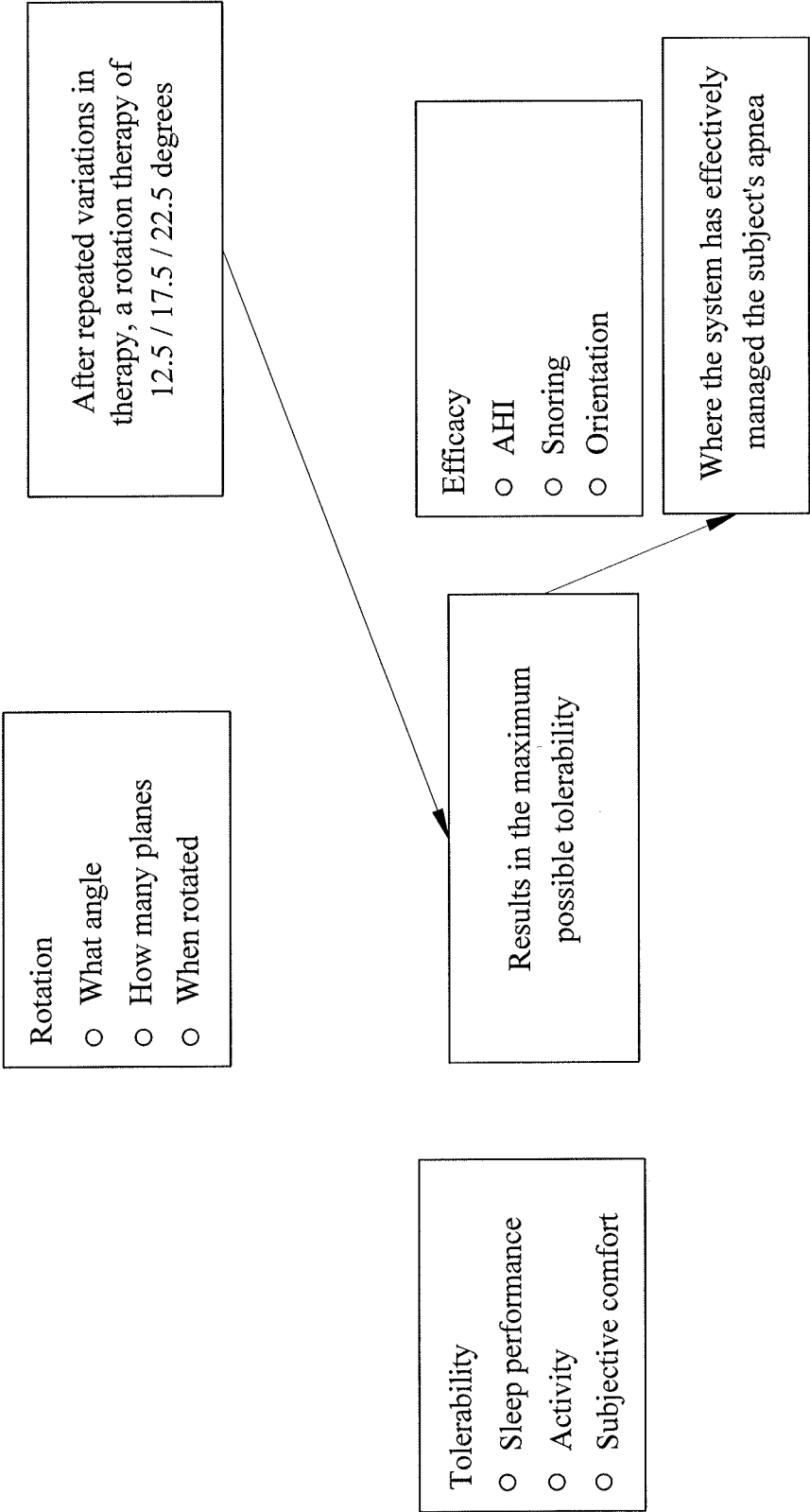


FIG. 40

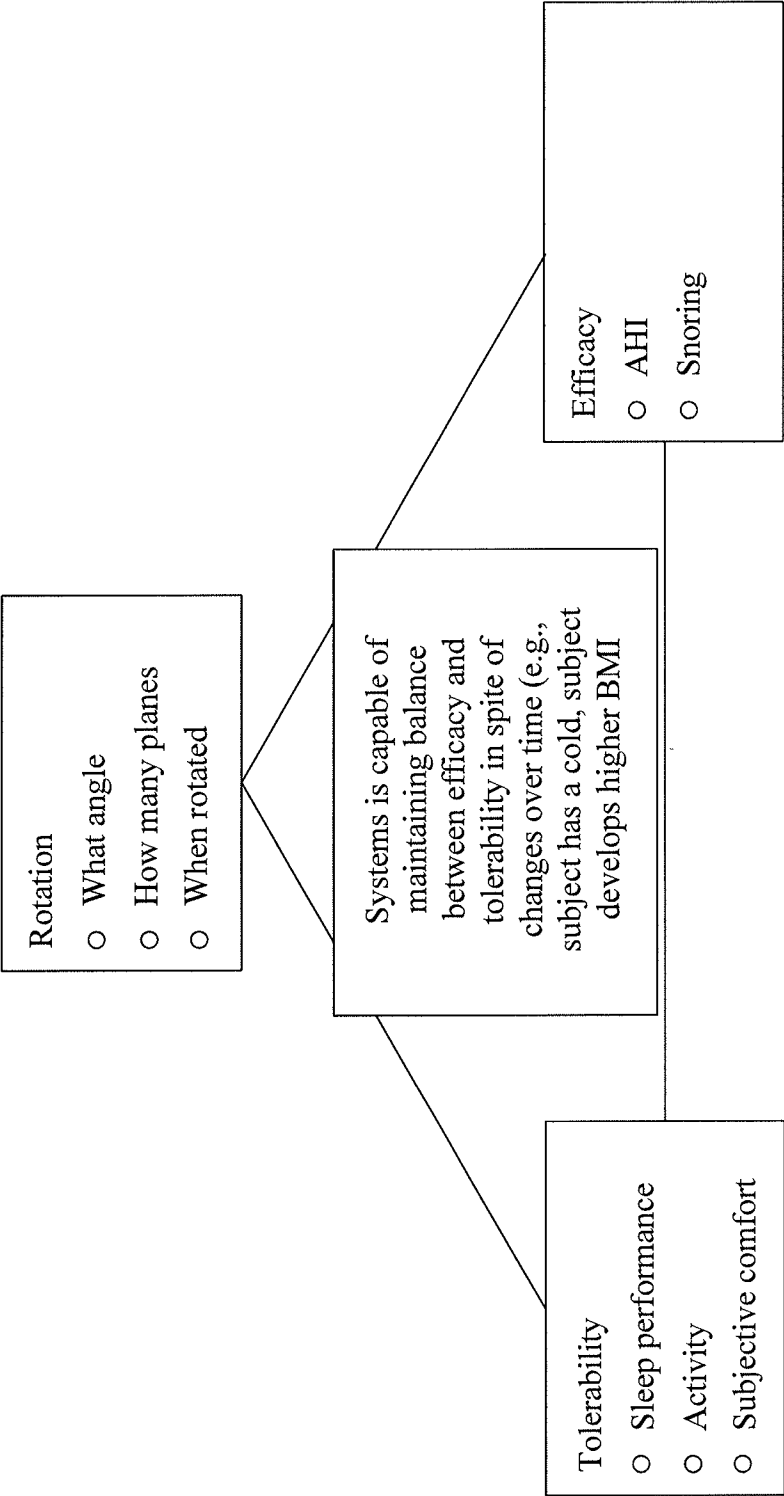


FIG. 41

Addition of apnea setting to device controls:

- Ability to specify rotation (how many rotation planes, dimensions of each plane, angle of rotation for each plane)

Modification of rotation function

- Constrained rotation at mid and upper section (e.g., by pressure modification, by physical constrain)
- Supplemented rotation via cushion

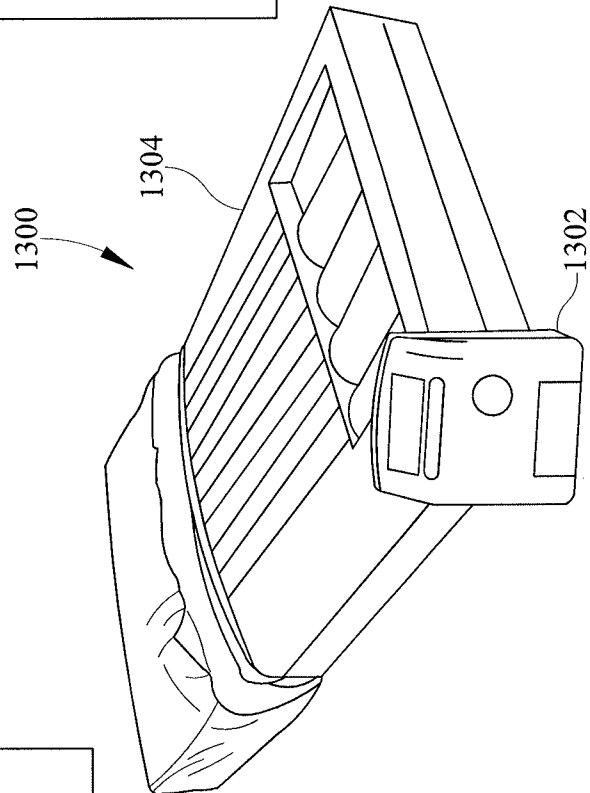


FIG. 42

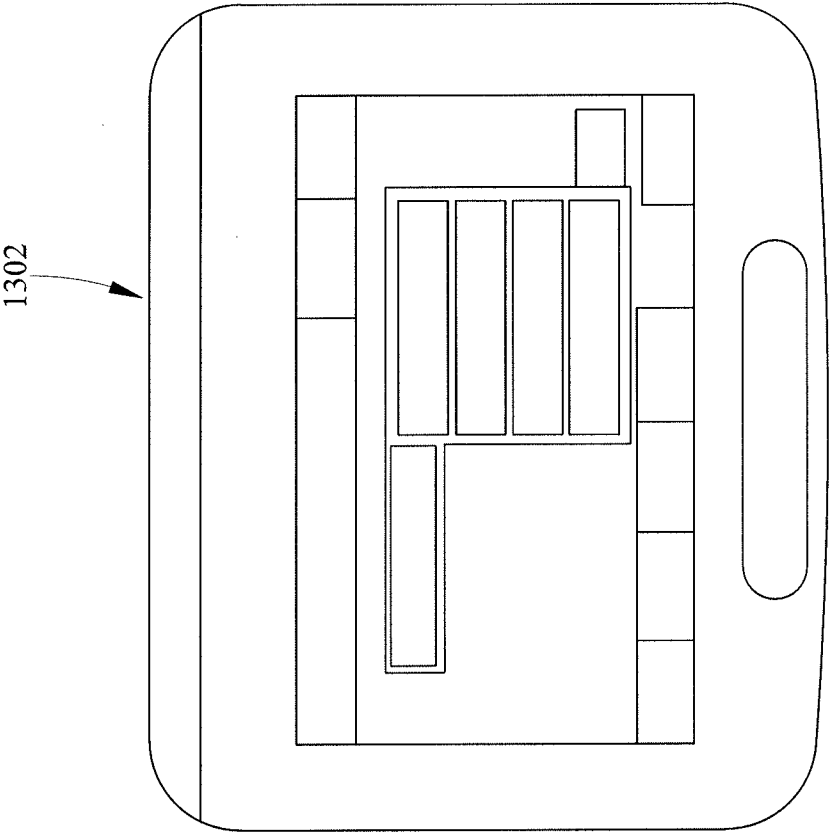


FIG. 43

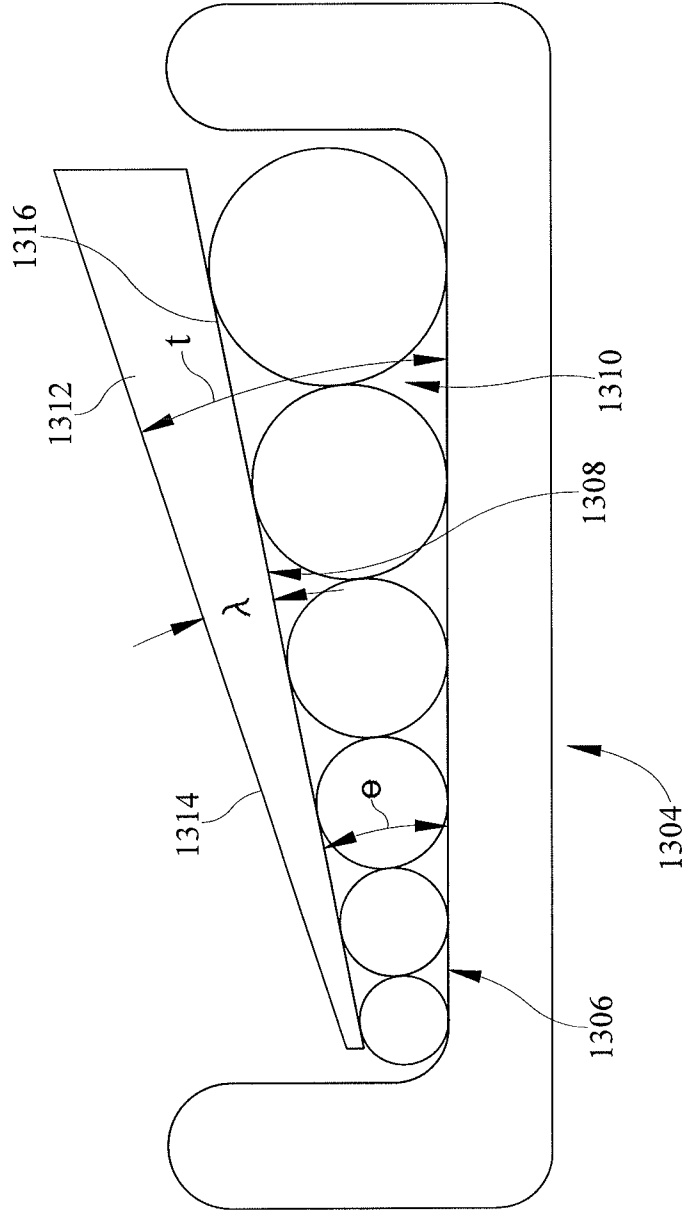


FIG. 44

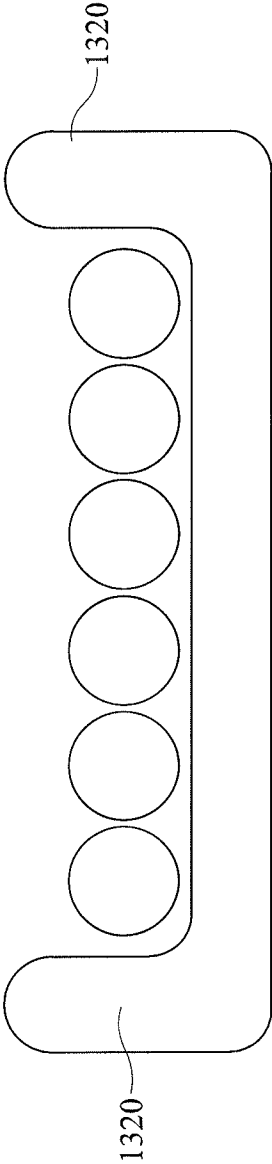


FIG. 45

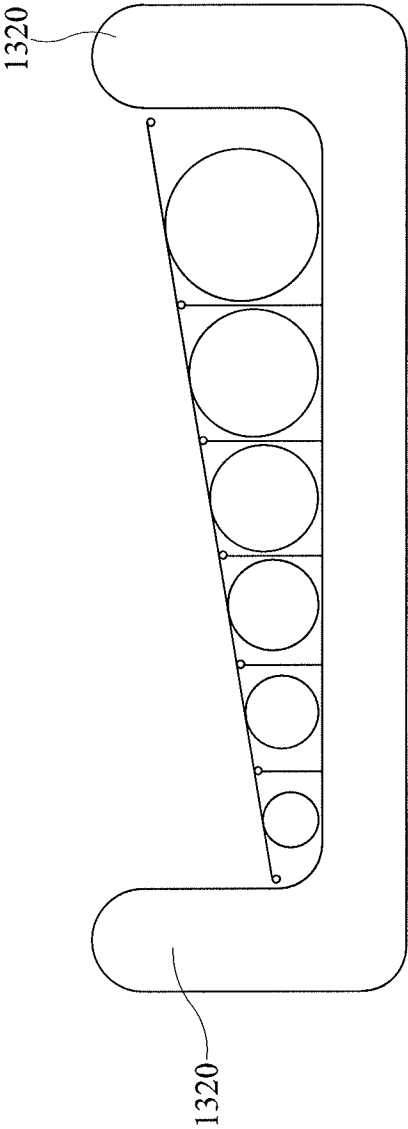


FIG. 46

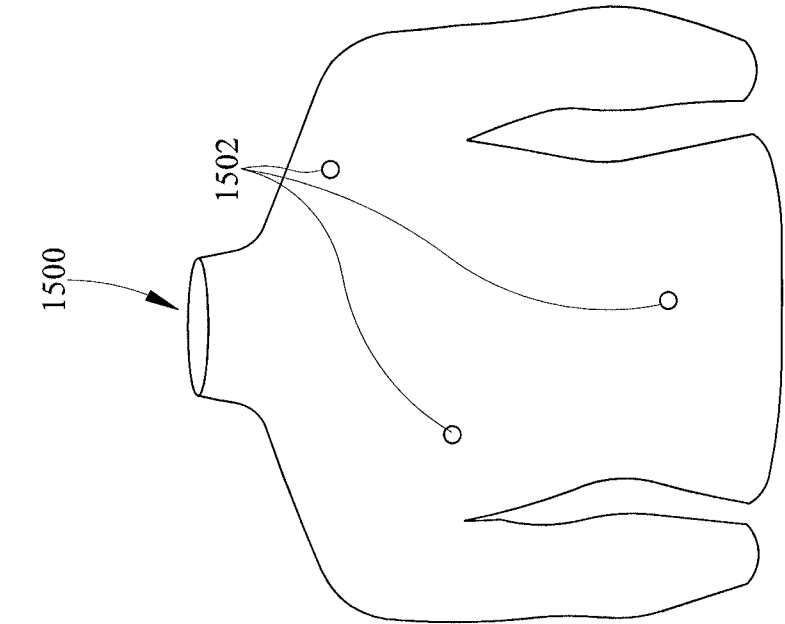


FIG. 47

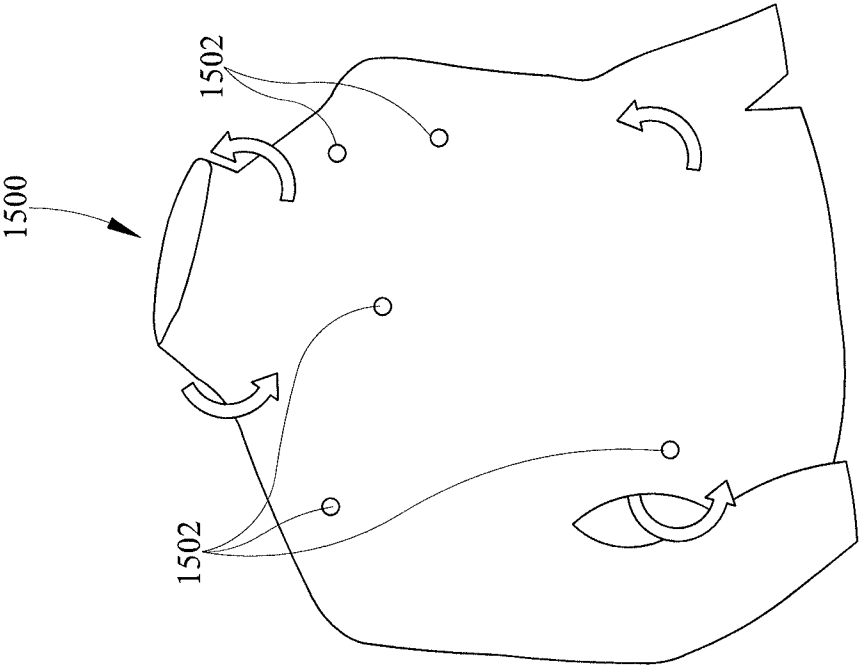


FIG. 48

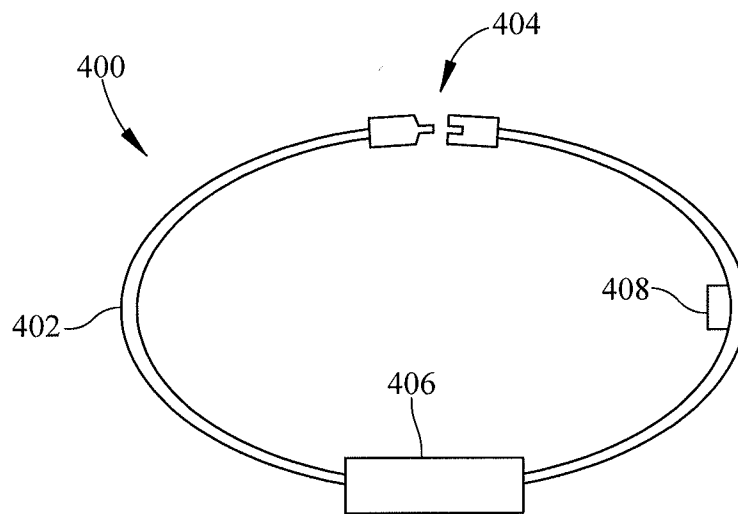


FIG. 49

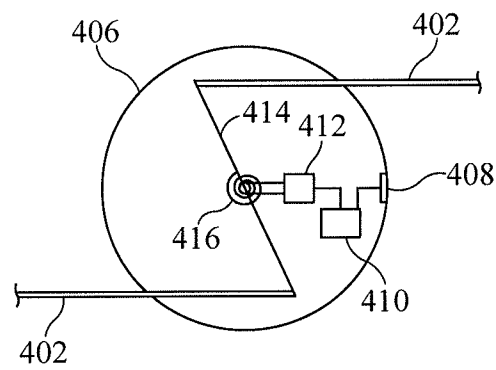


FIG. 50

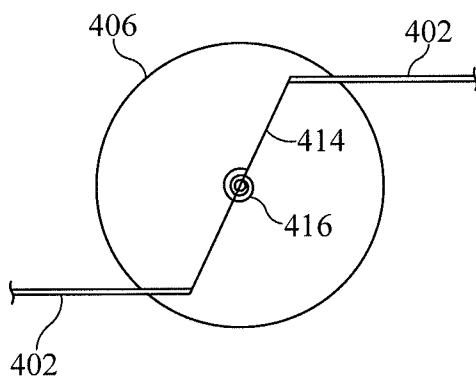


FIG. 51

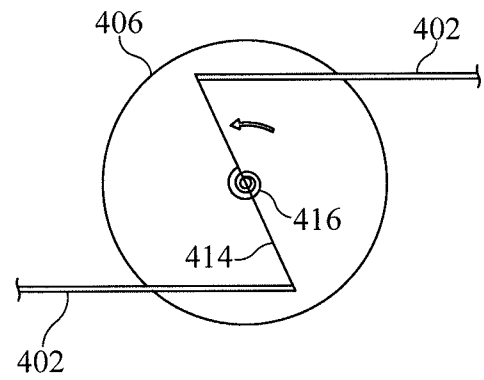


FIG. 52

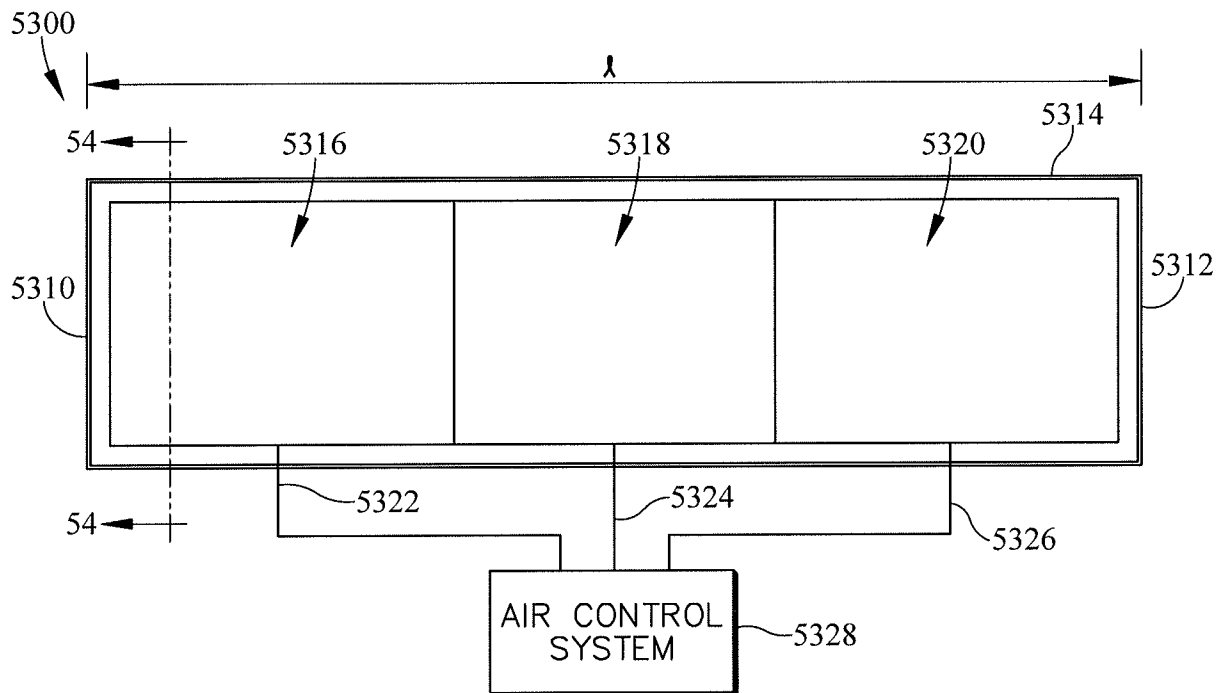


FIG. 53

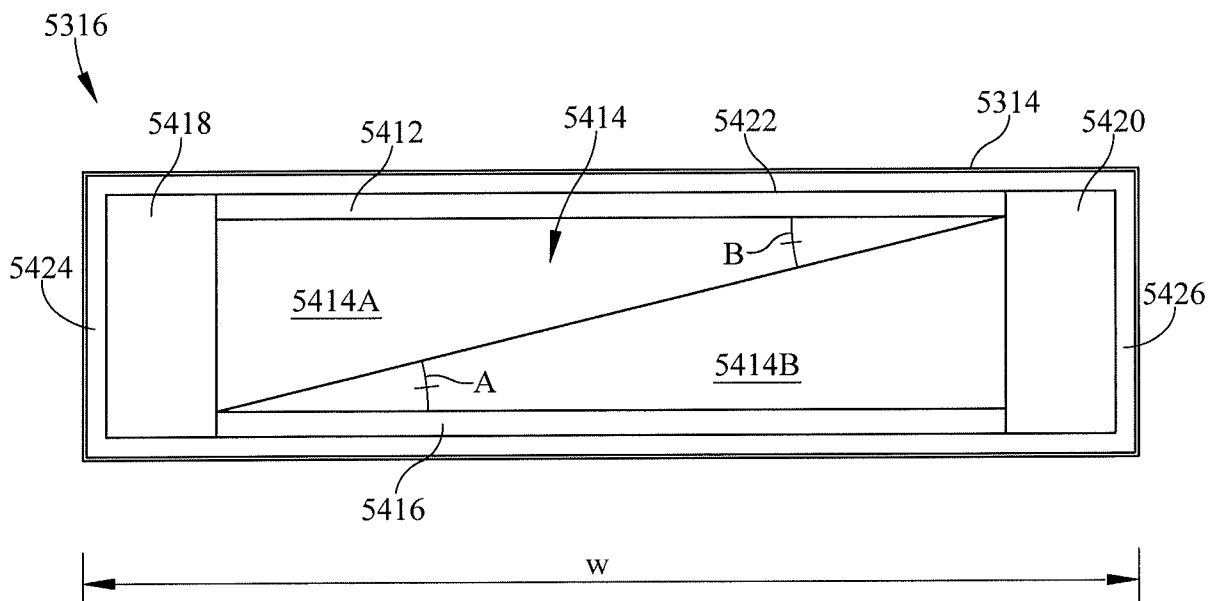


FIG. 54

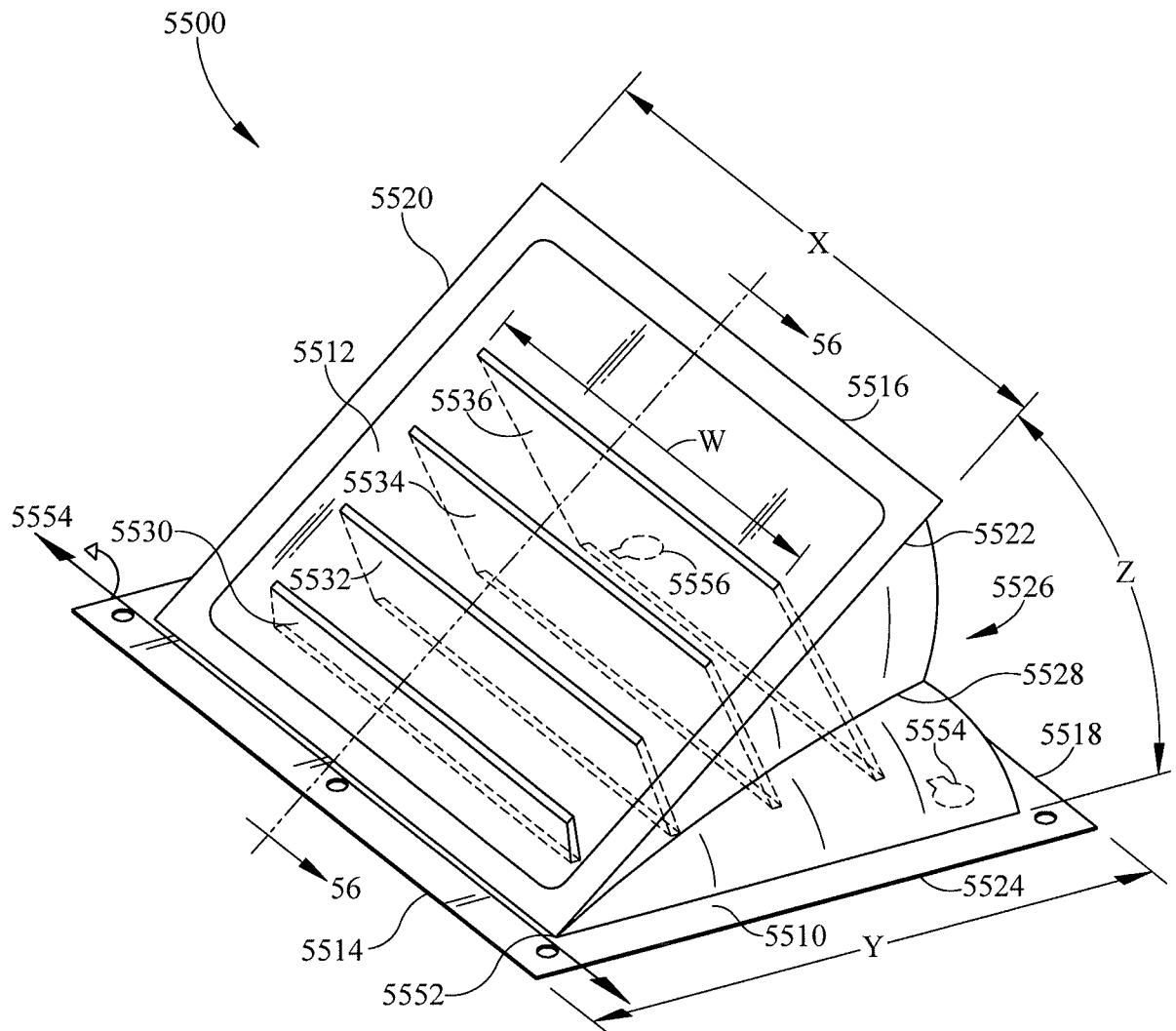


FIG. 55

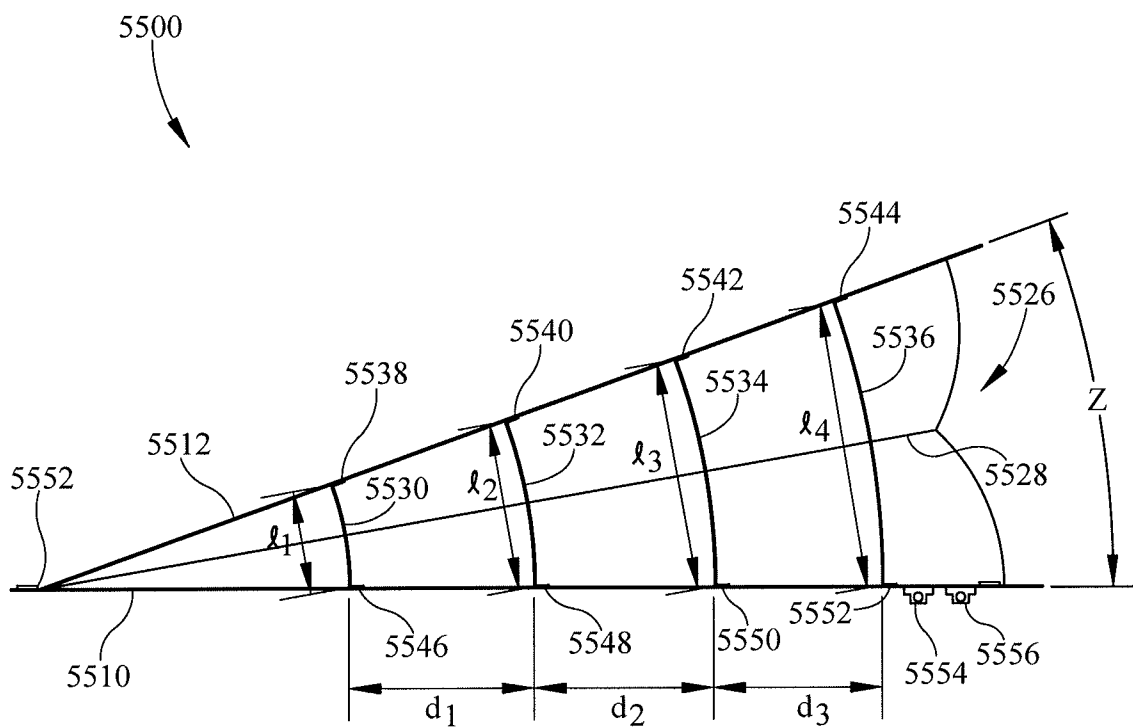


FIG.56

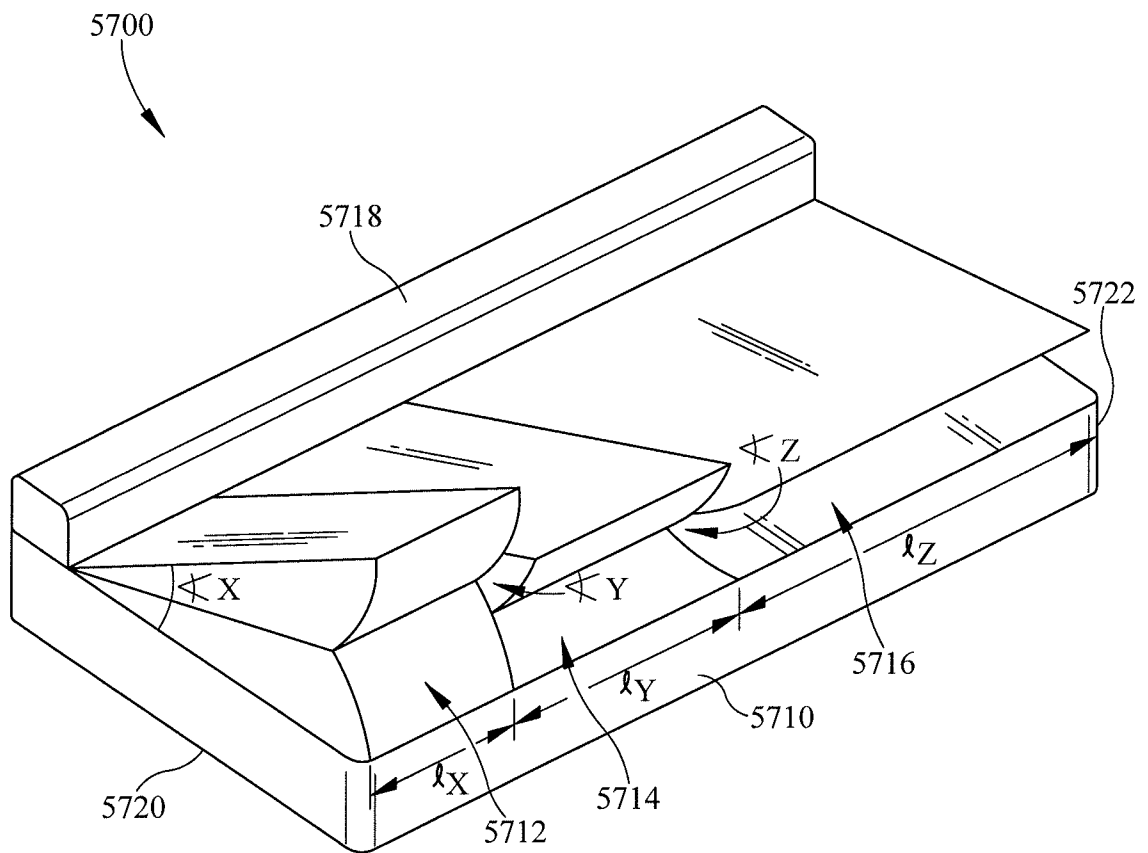
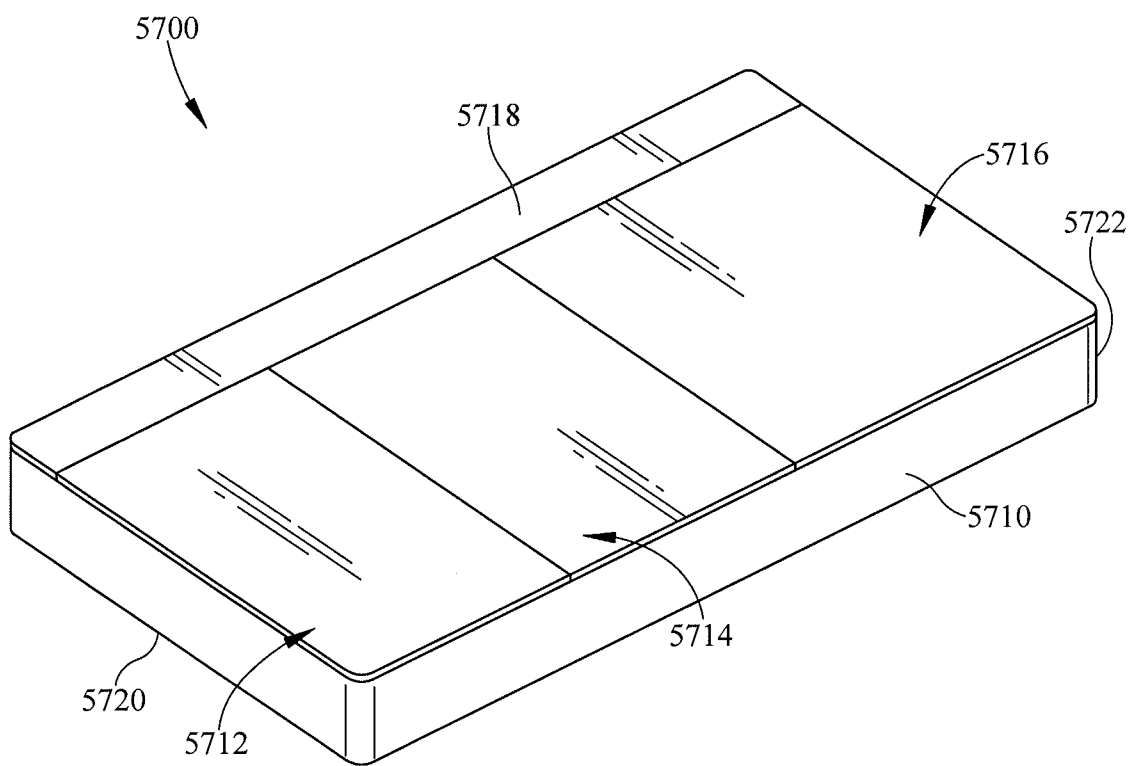


FIG. 57

*FIG. 58*

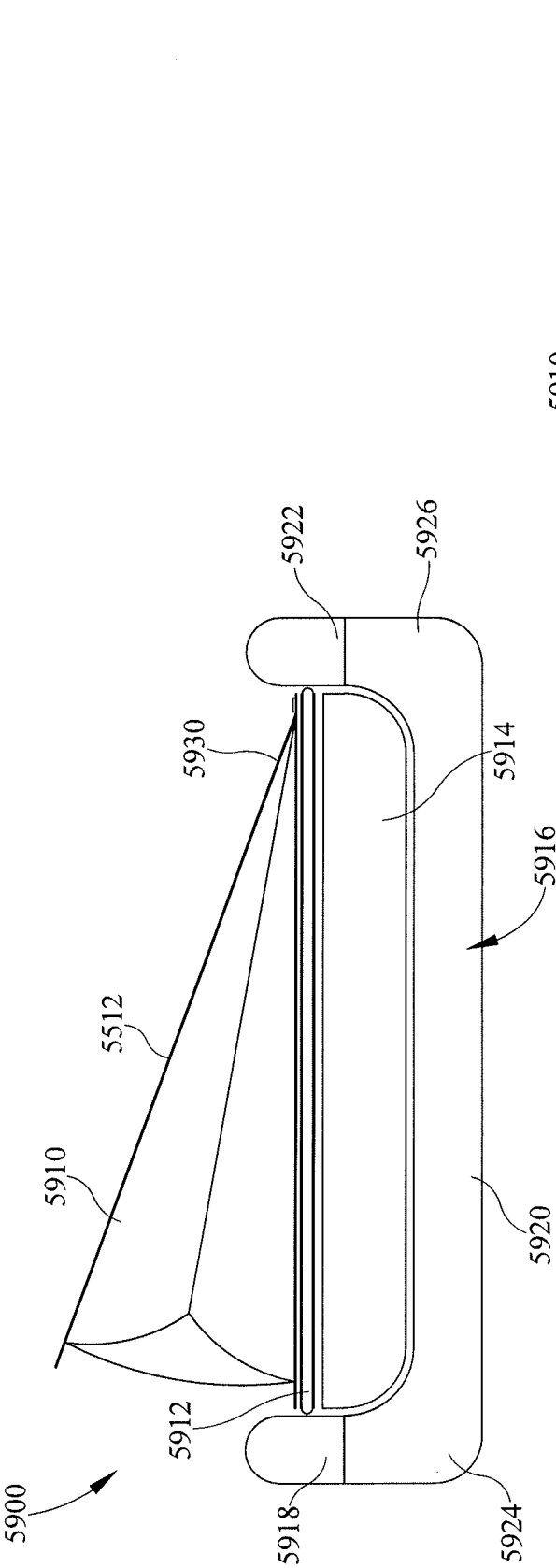


FIG. 59

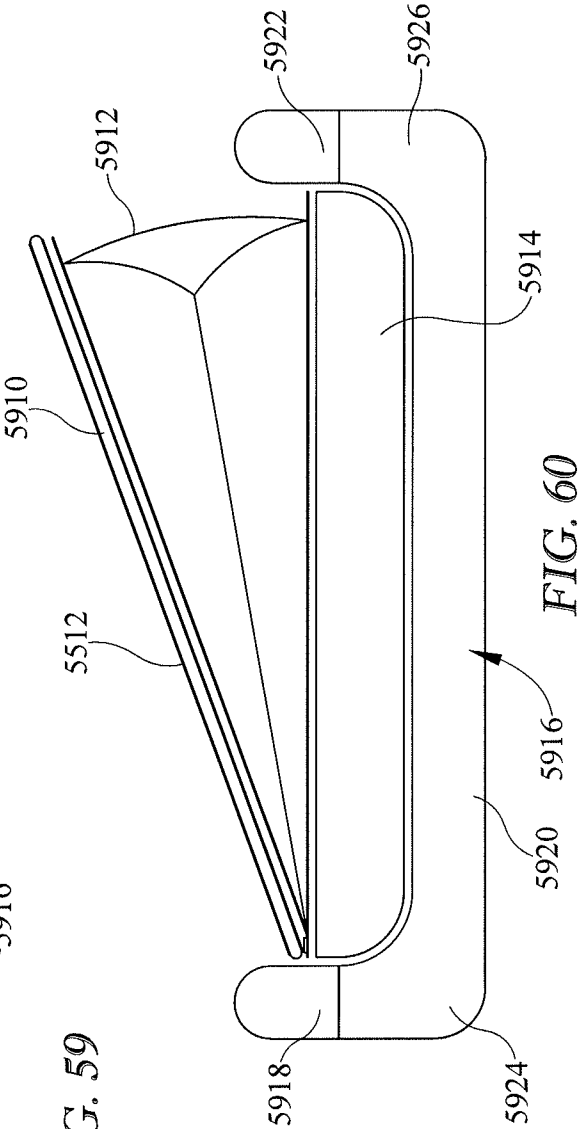


FIG. 60

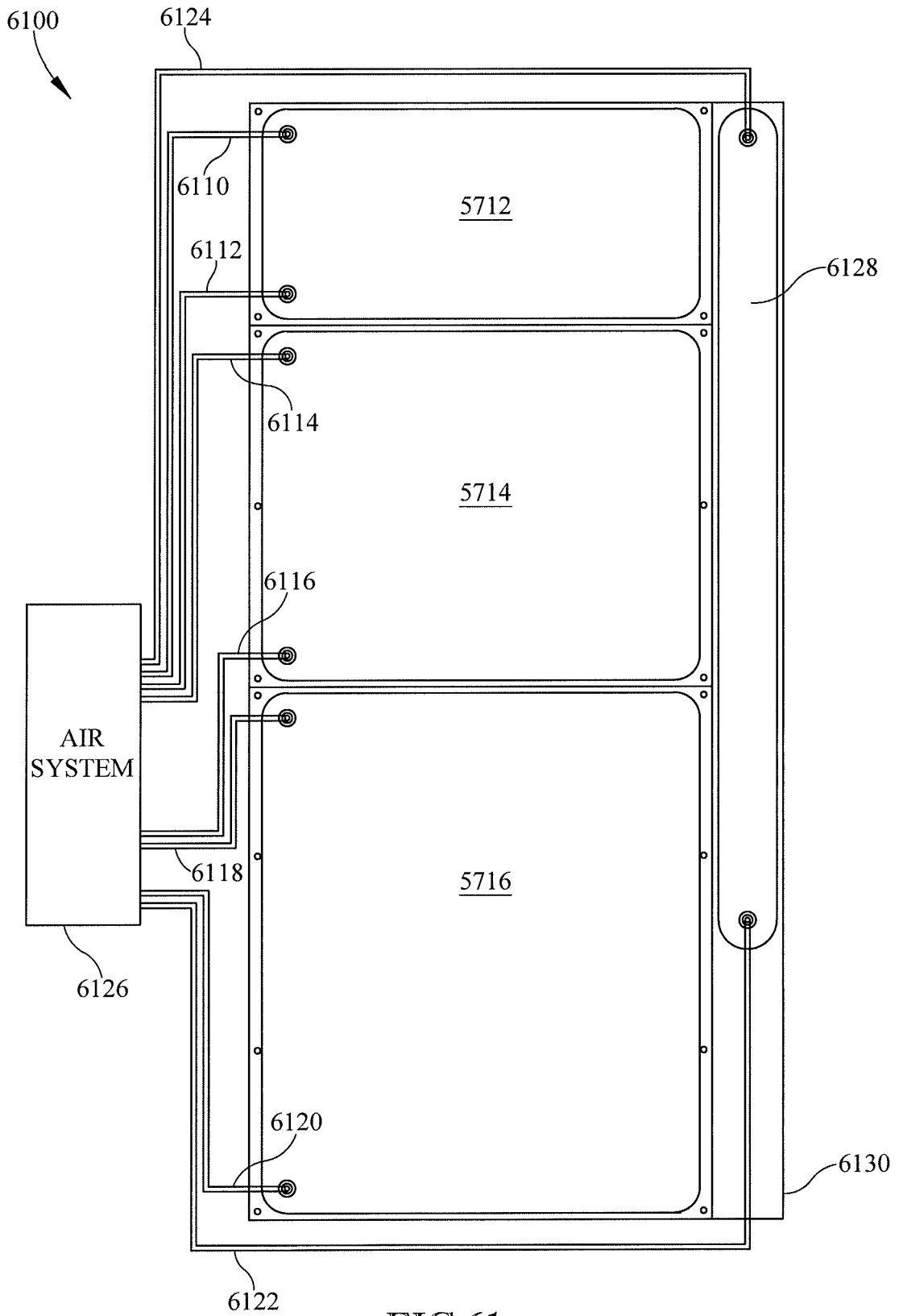


FIG.61

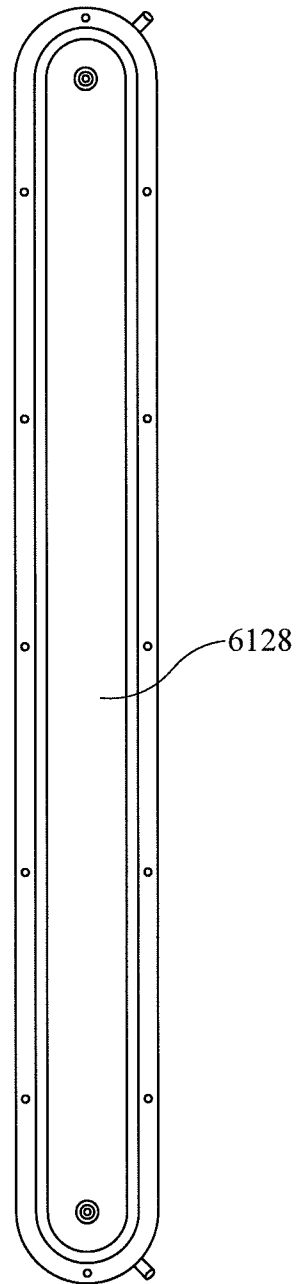


FIG. 62

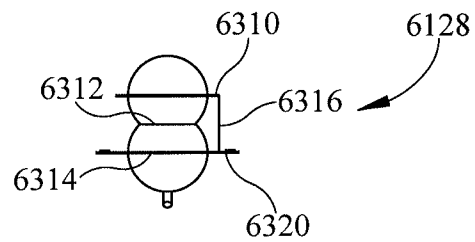
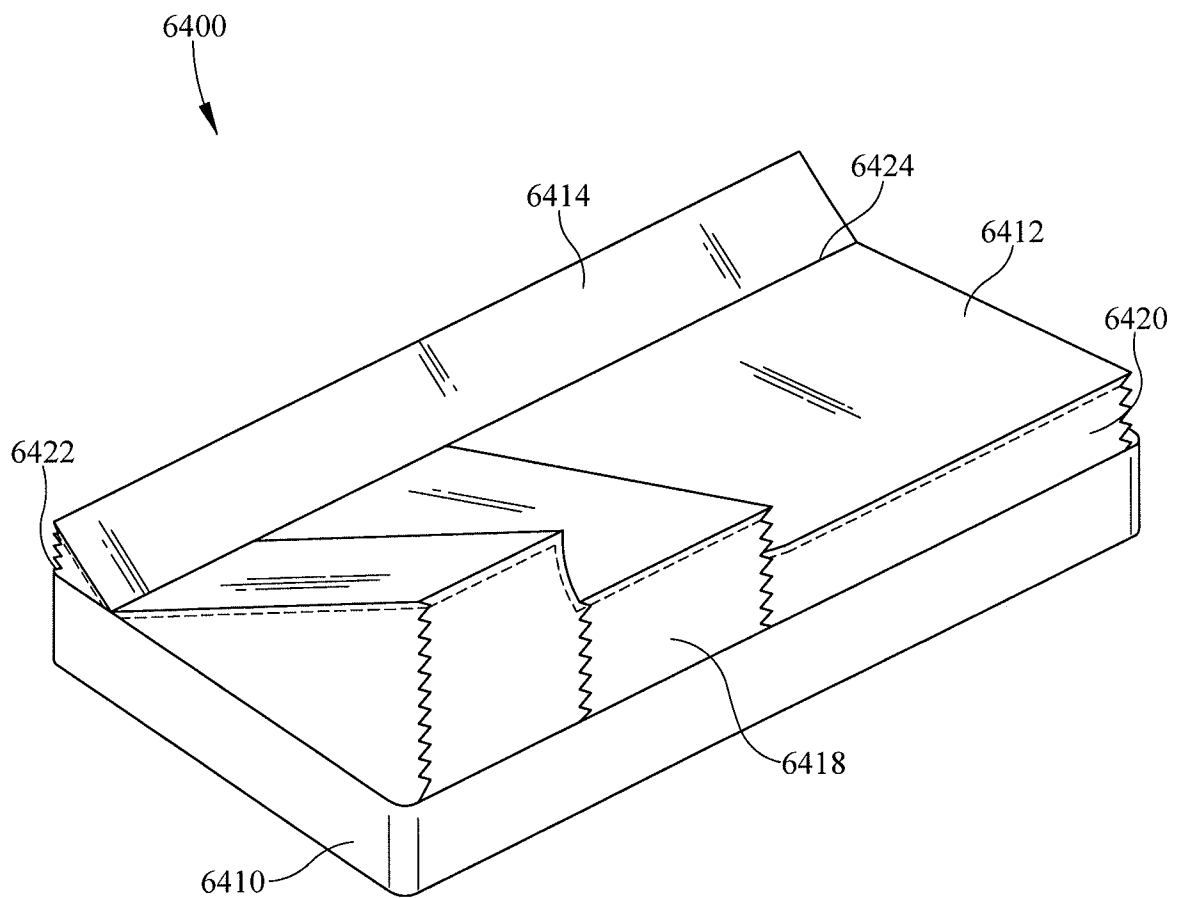
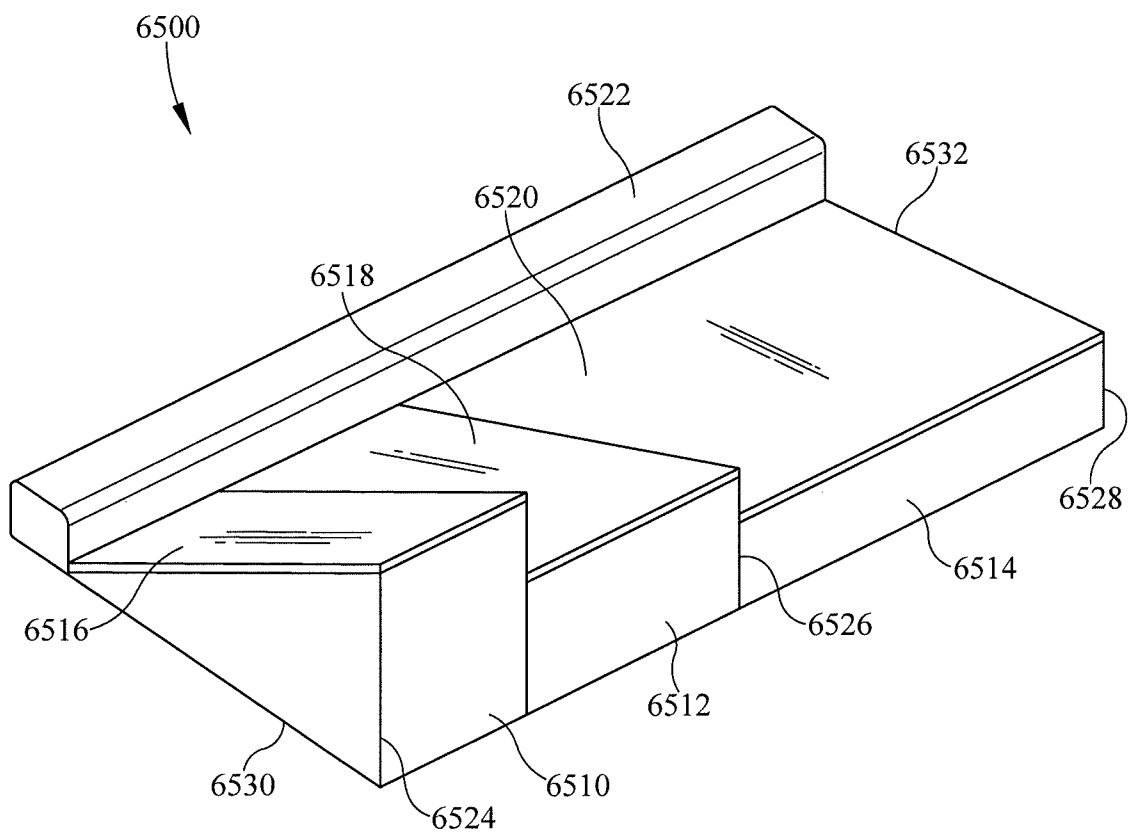
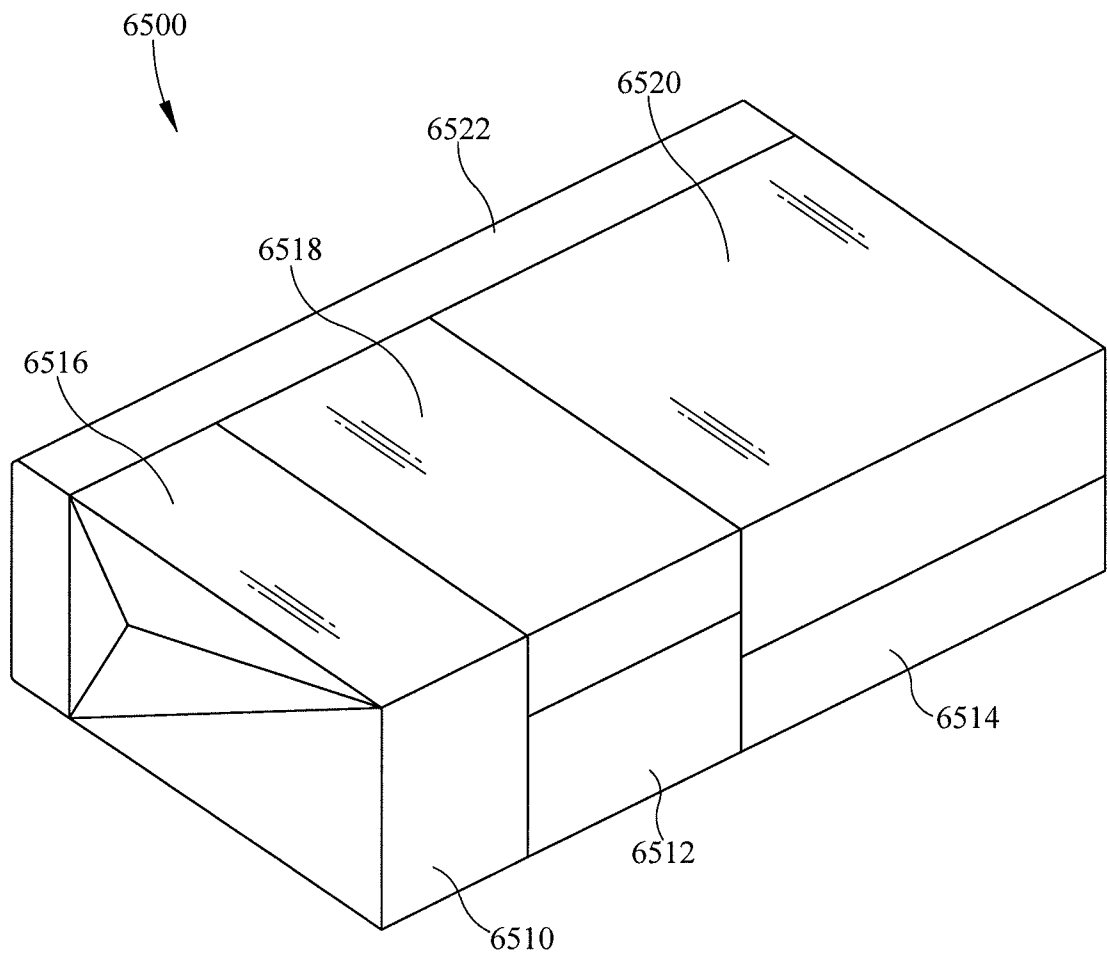


FIG. 63

*FIG. 64*

*FIG. 65*

*FIG. 66*

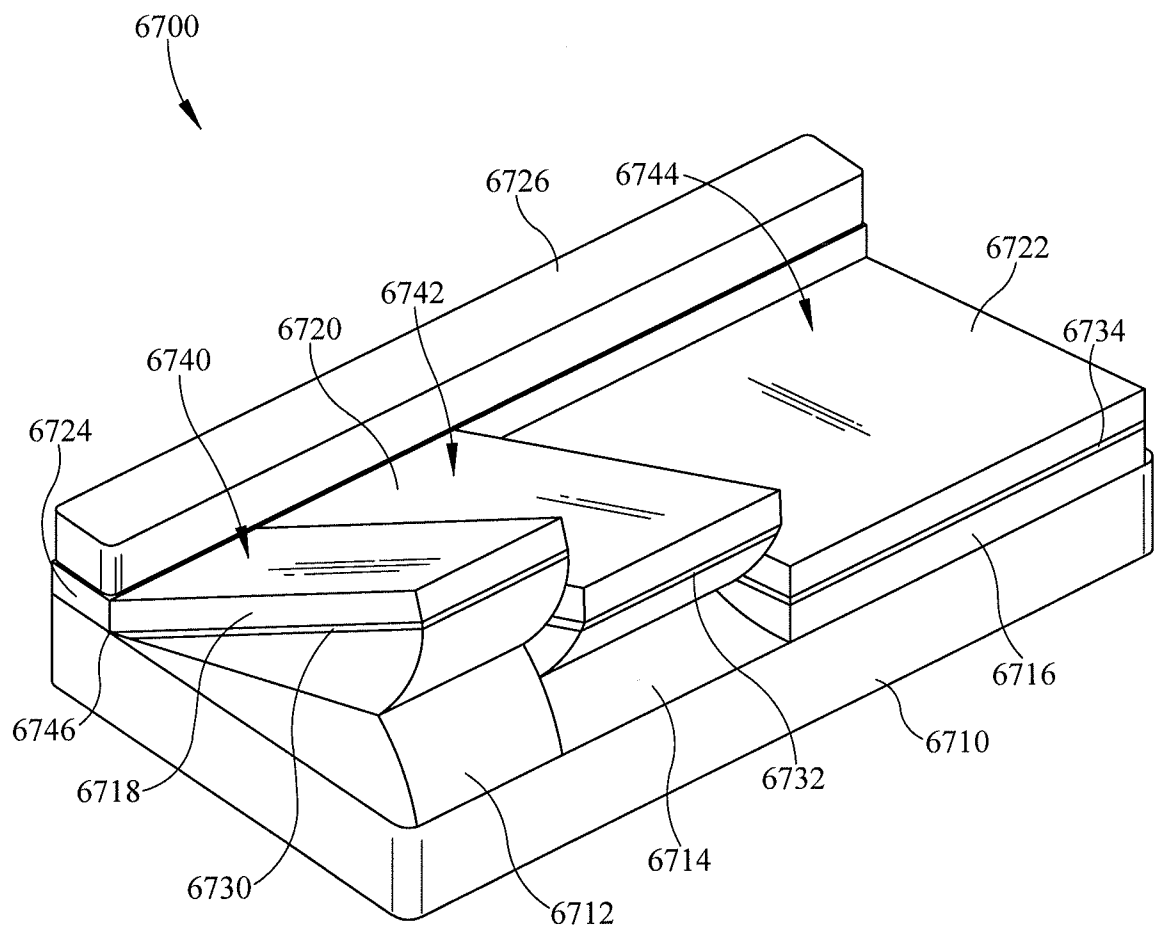
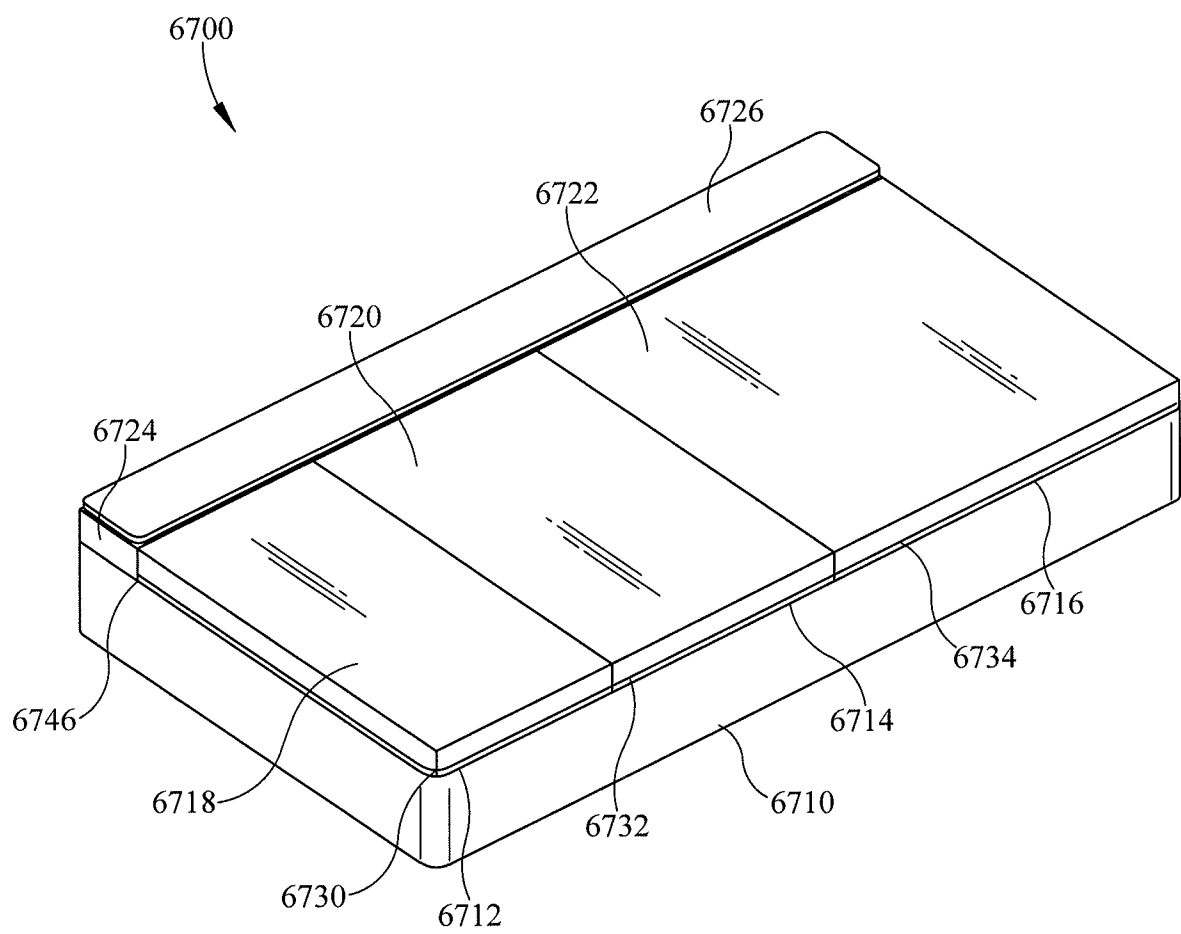


FIG. 67

*FIG. 68*

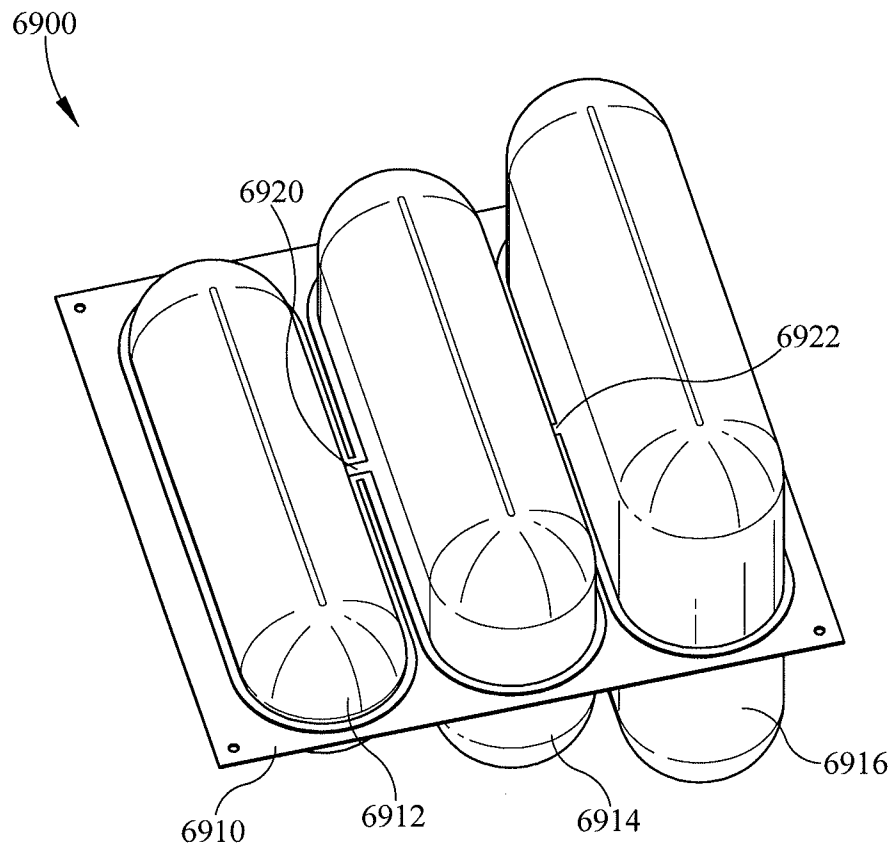


FIG. 69

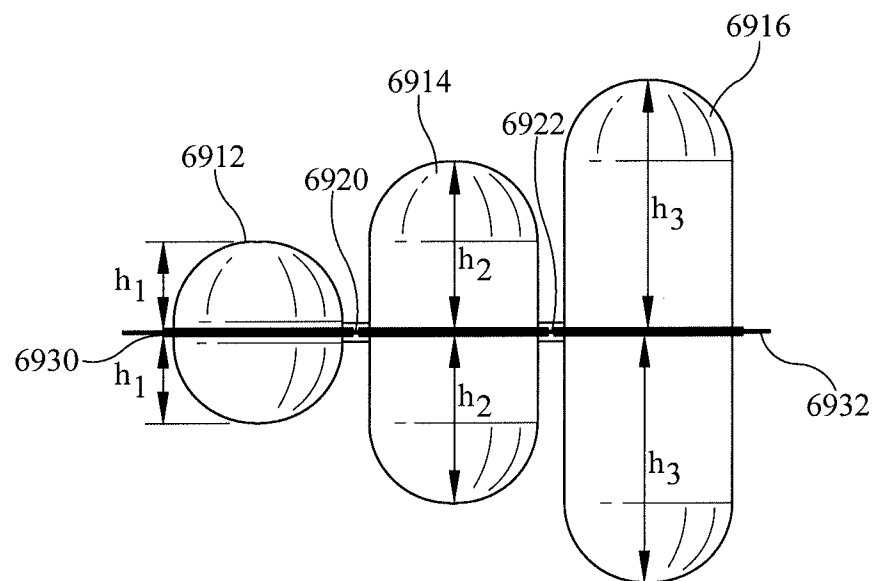
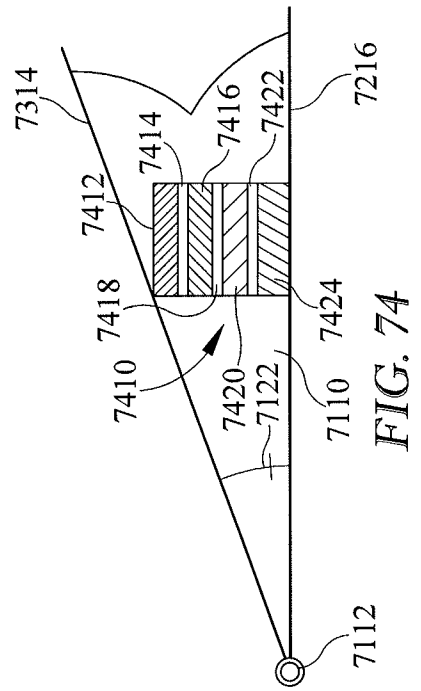
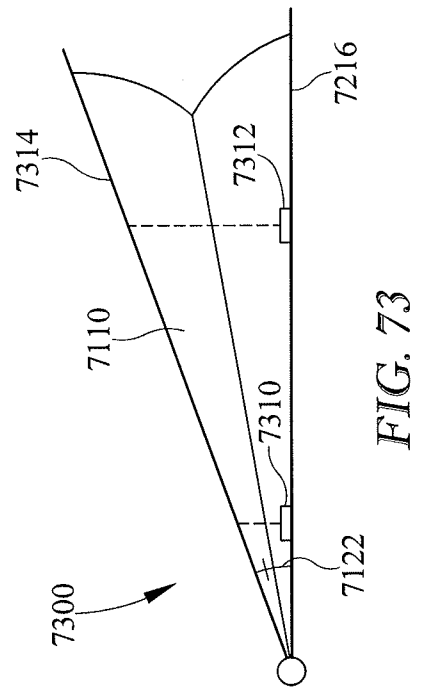
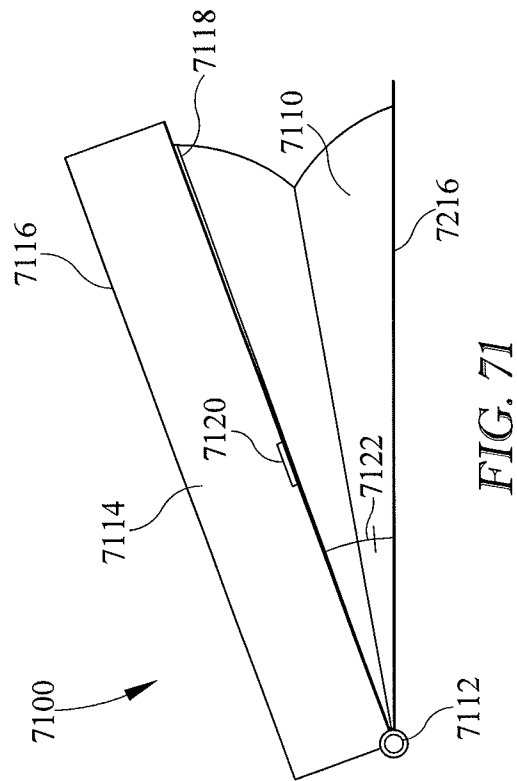
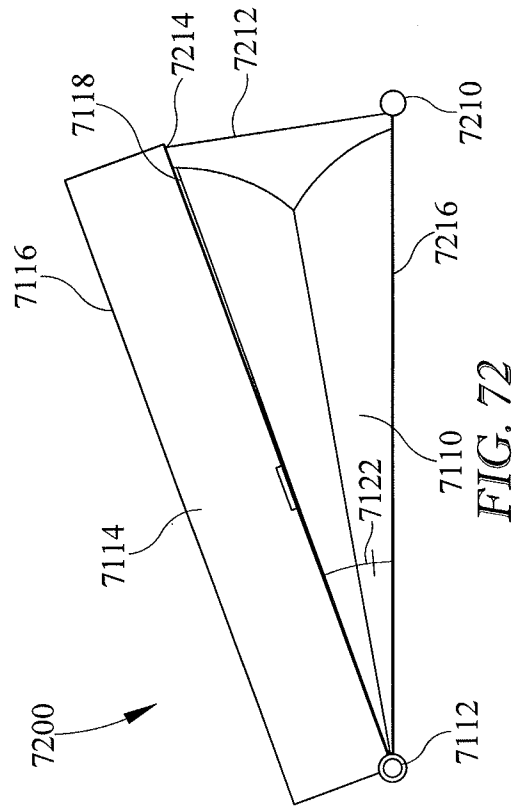


FIG. 70



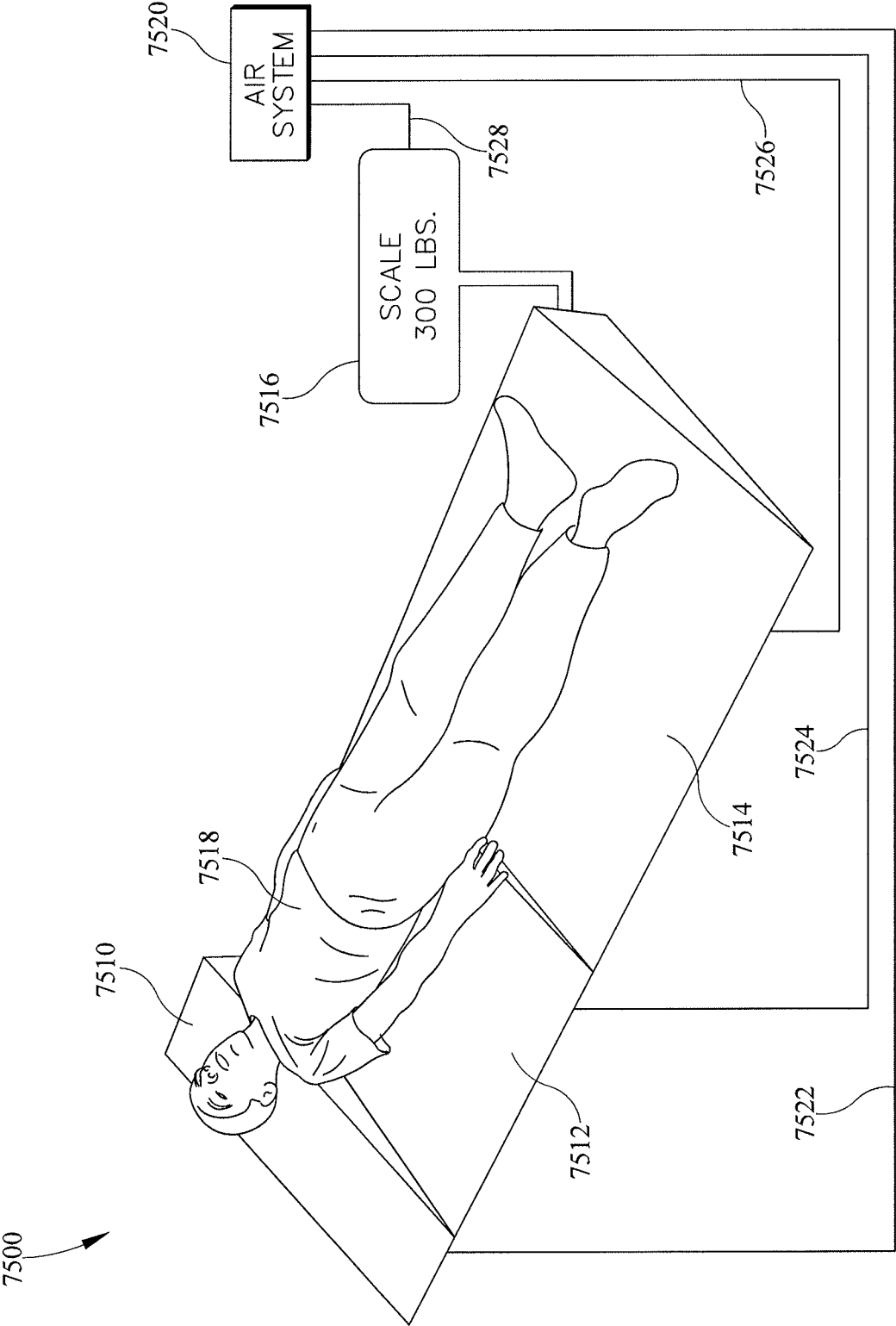


FIG. 75

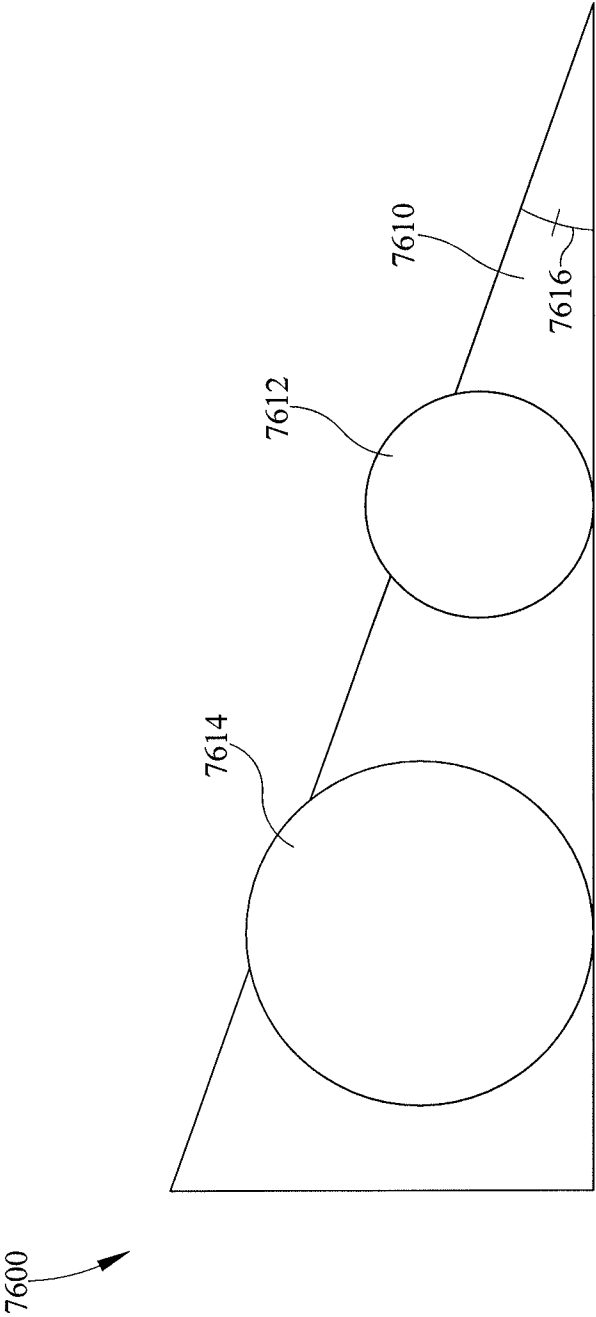


FIG. 76

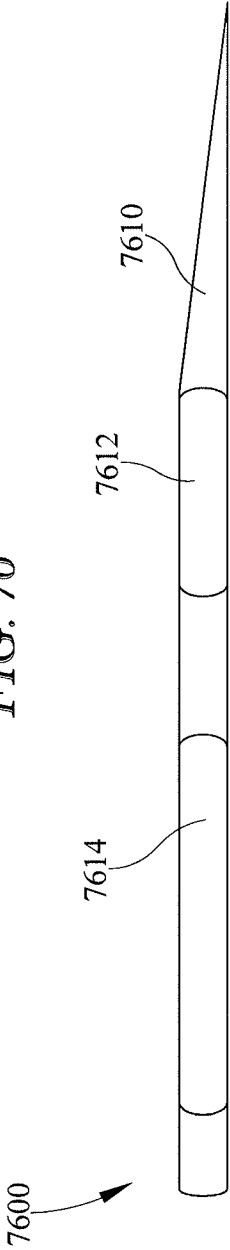
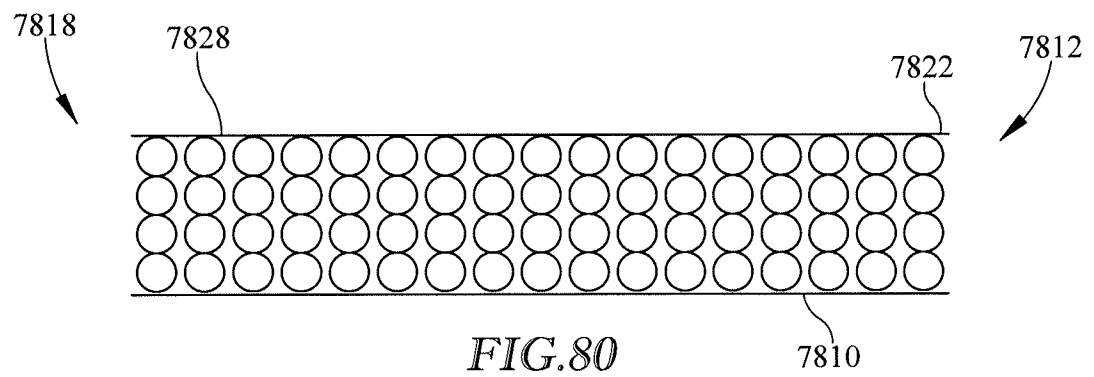
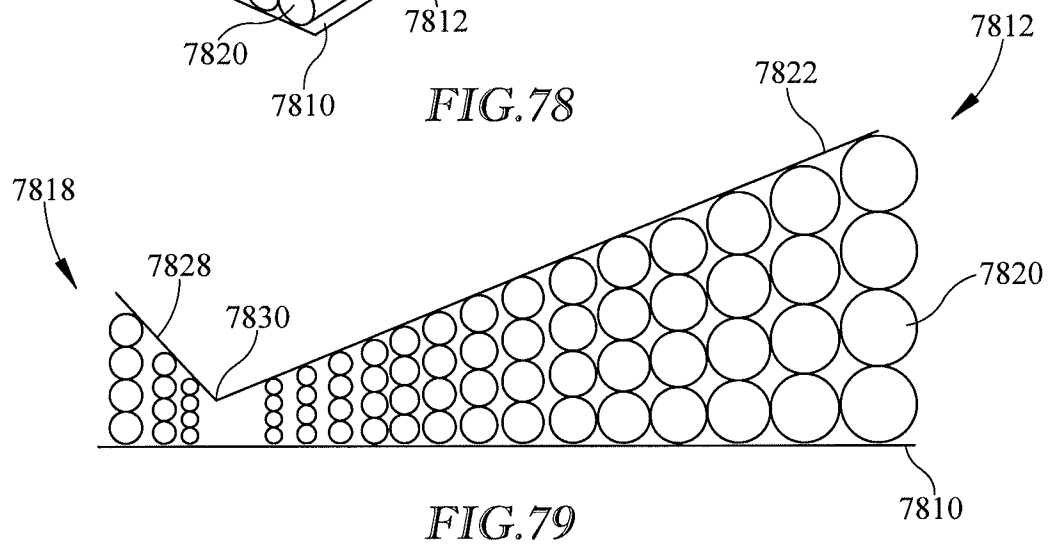
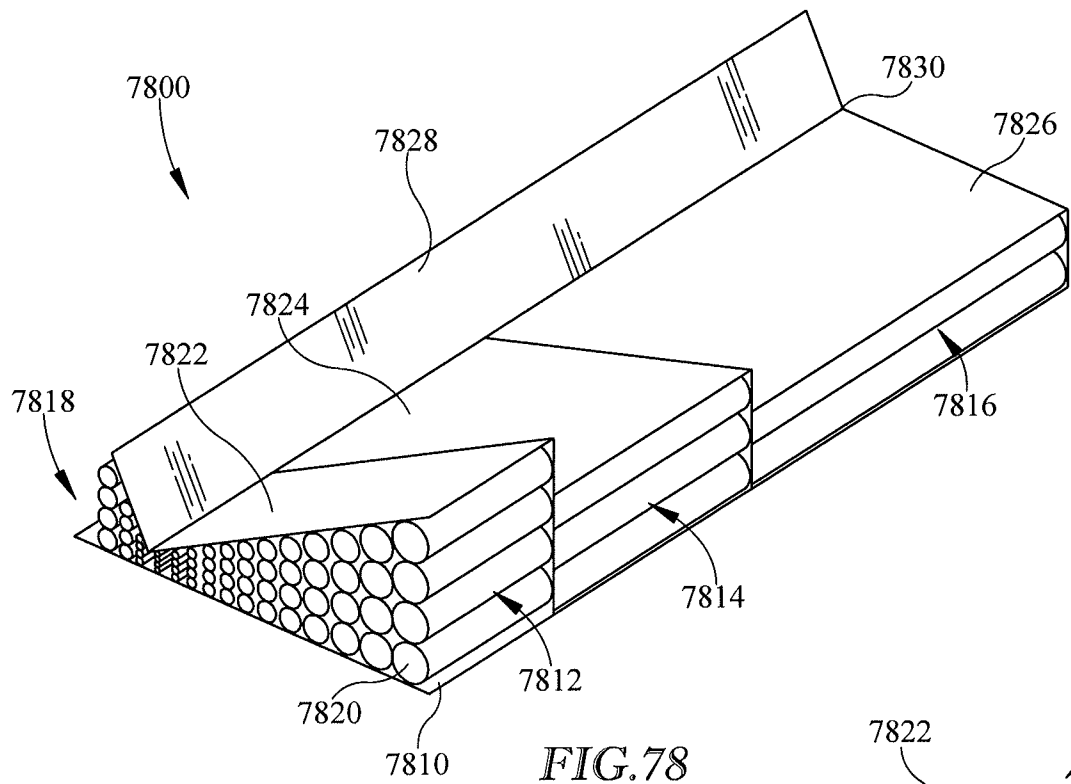
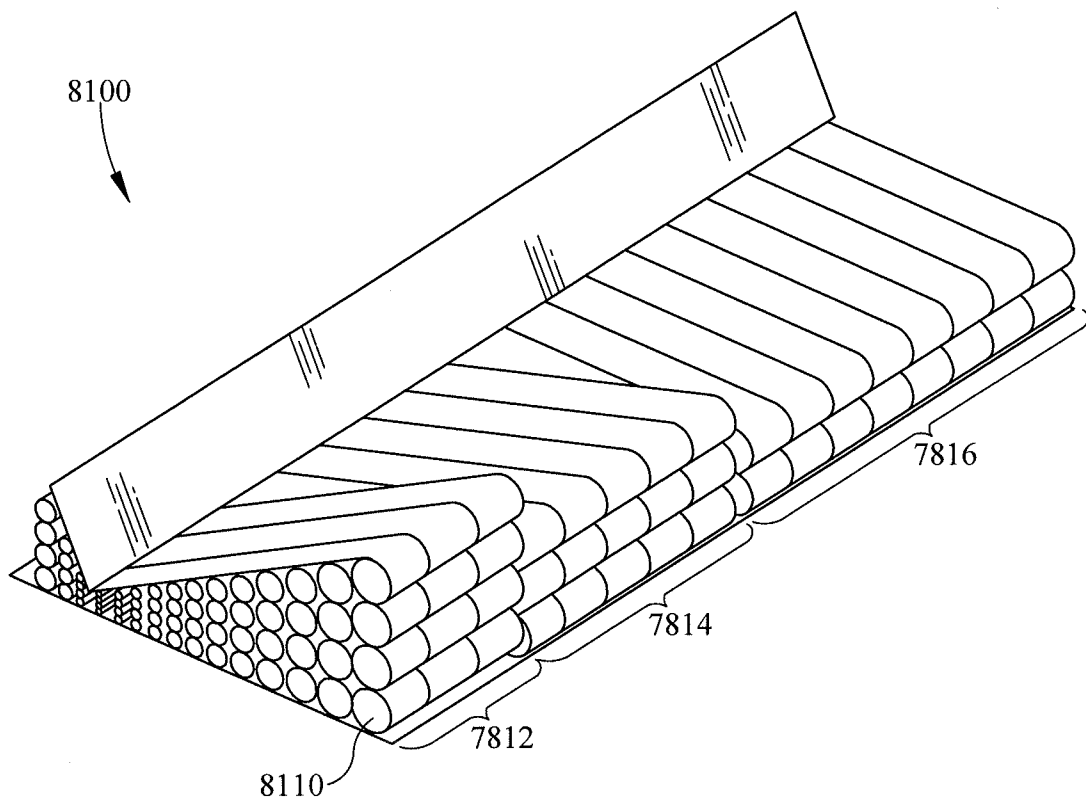
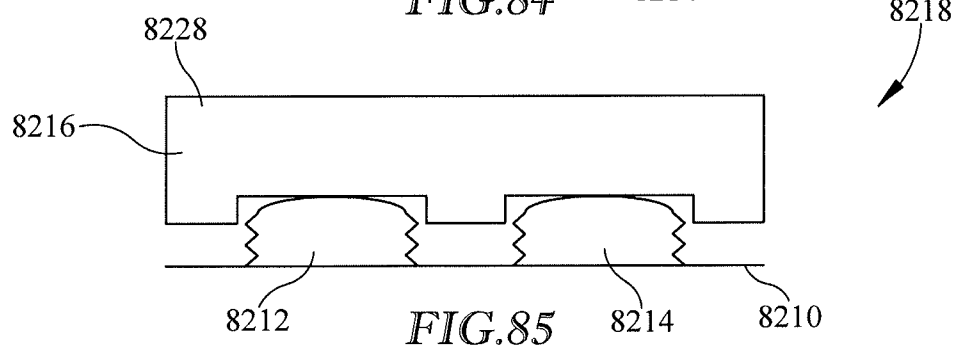
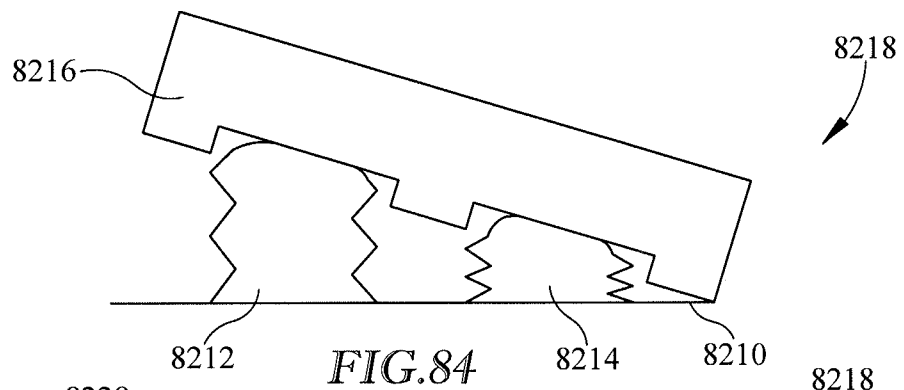
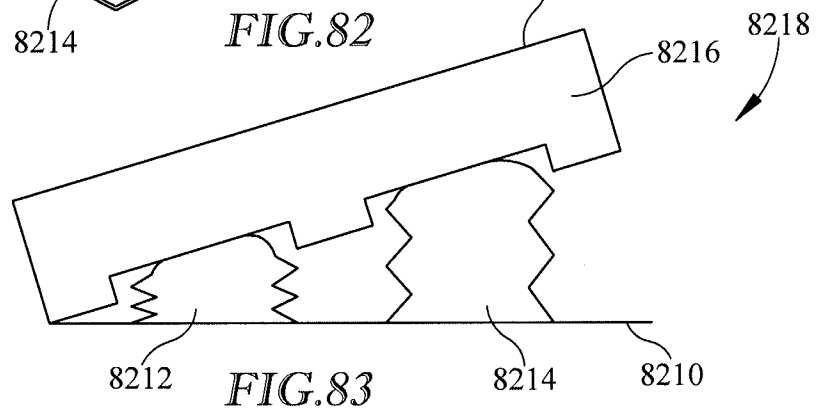
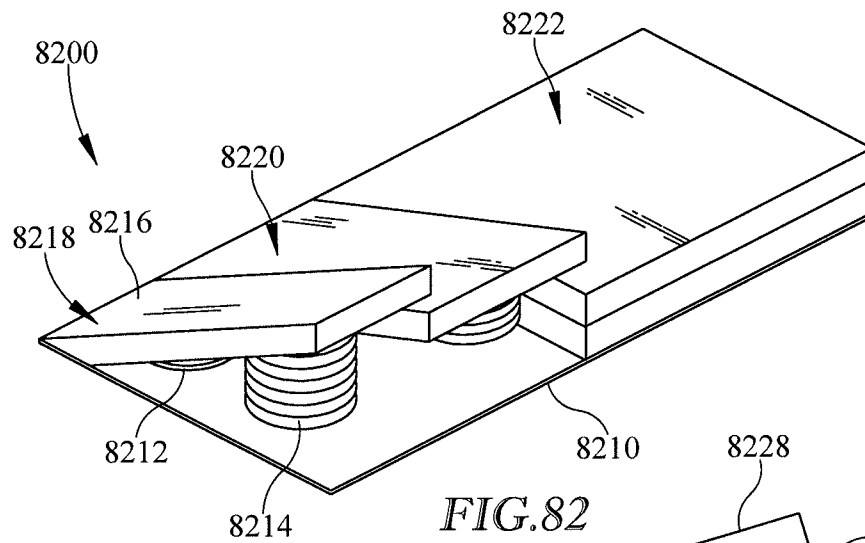
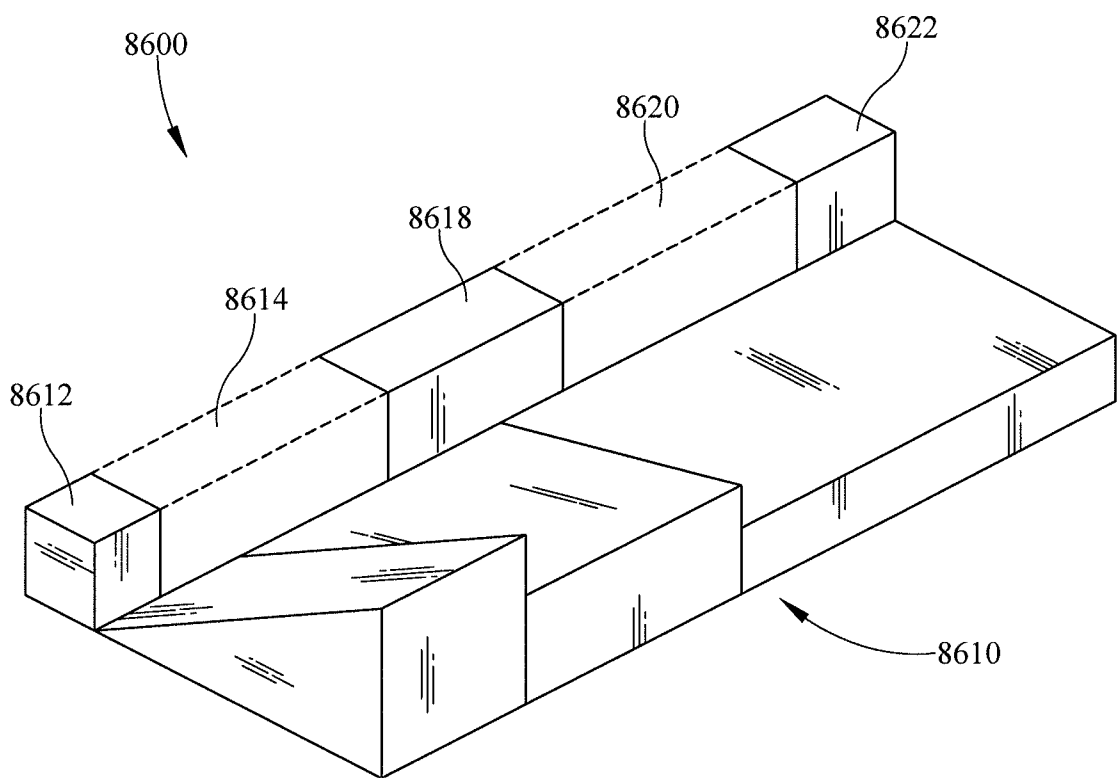


FIG. 77



*FIG. 81*



*FIG. 86*

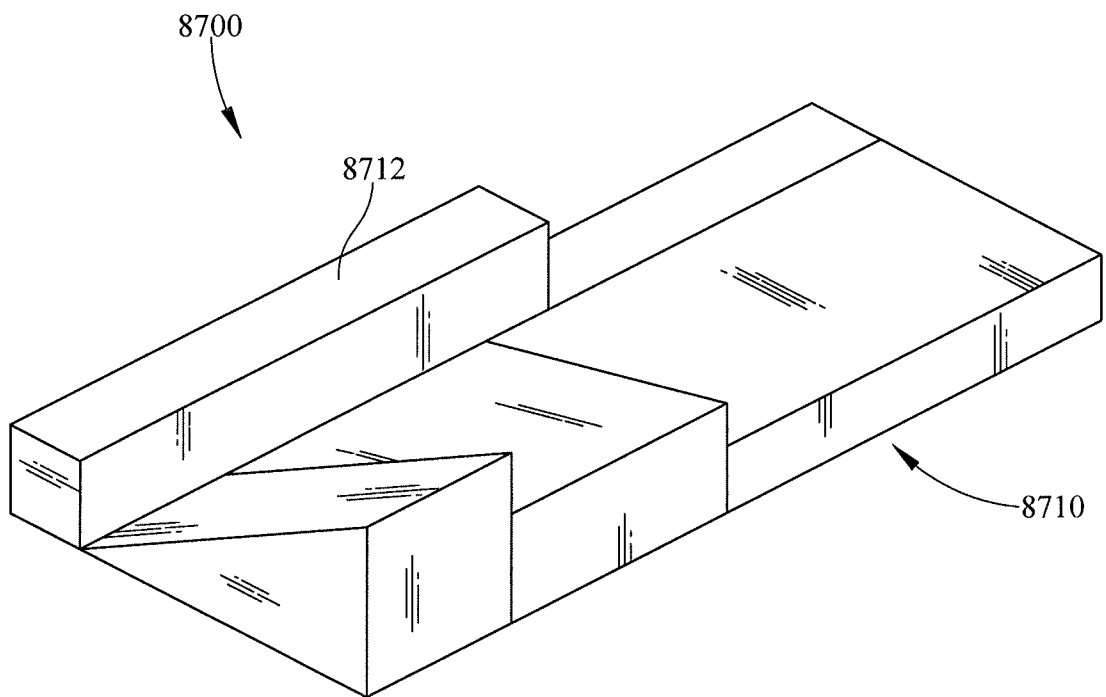
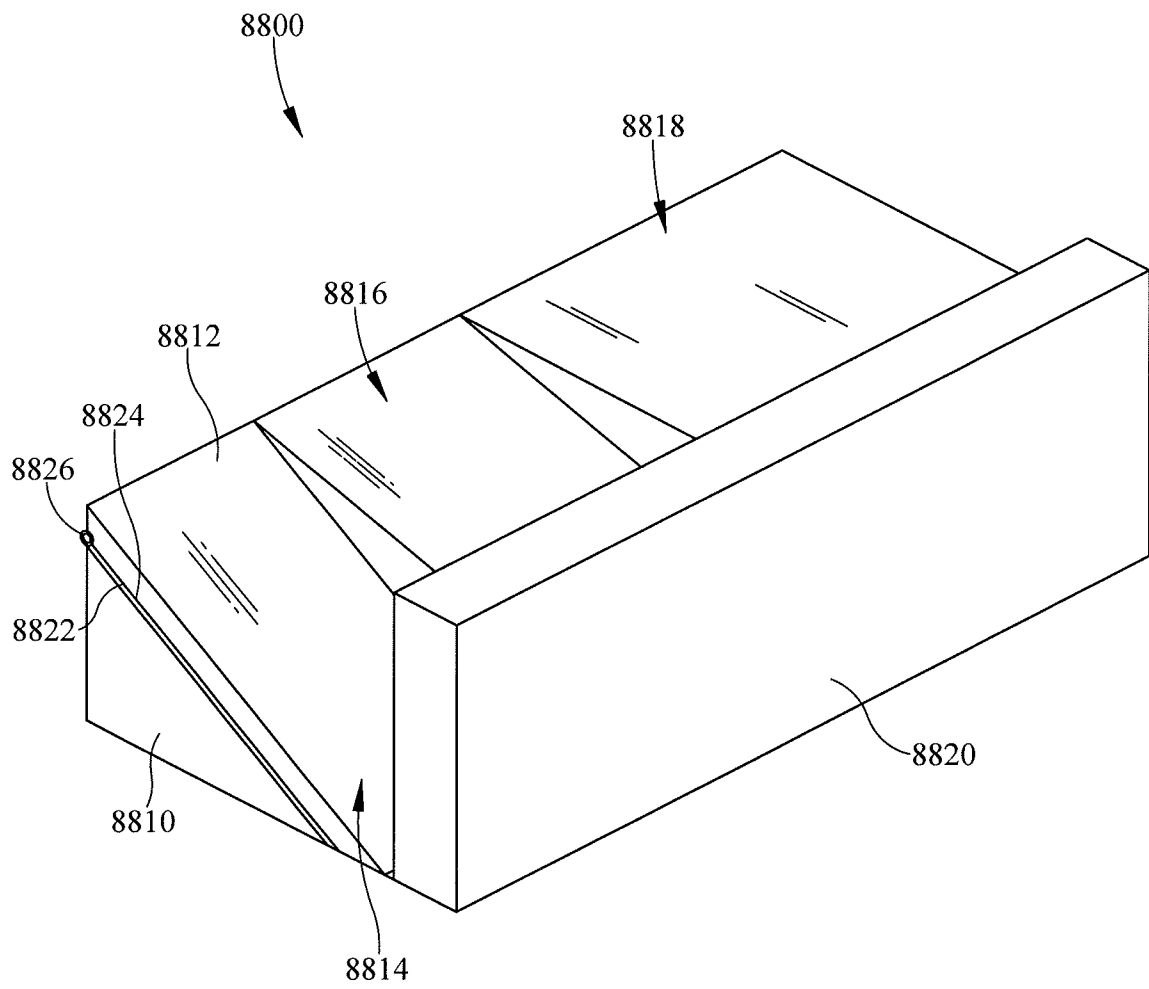
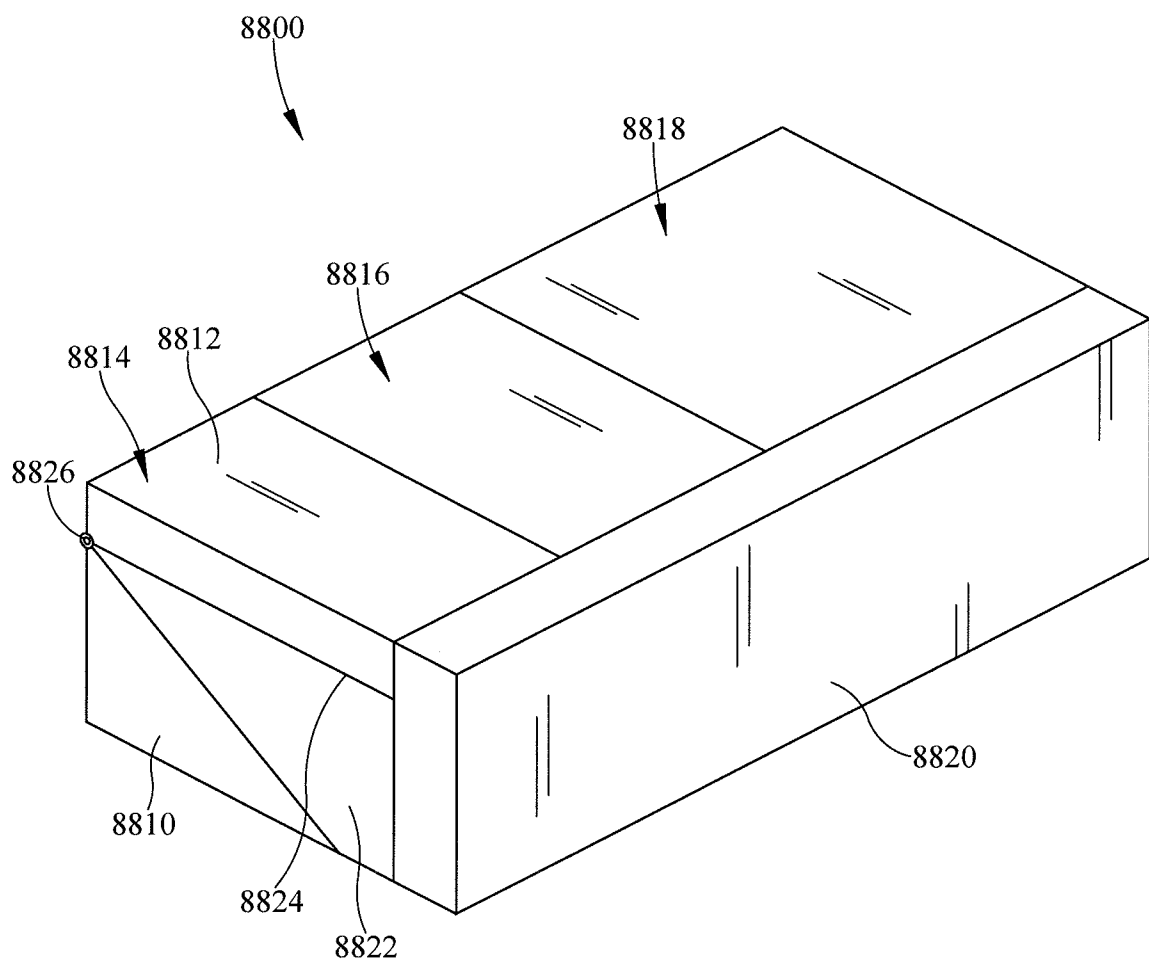


FIG.87

*FIG. 88*

*FIG. 89*

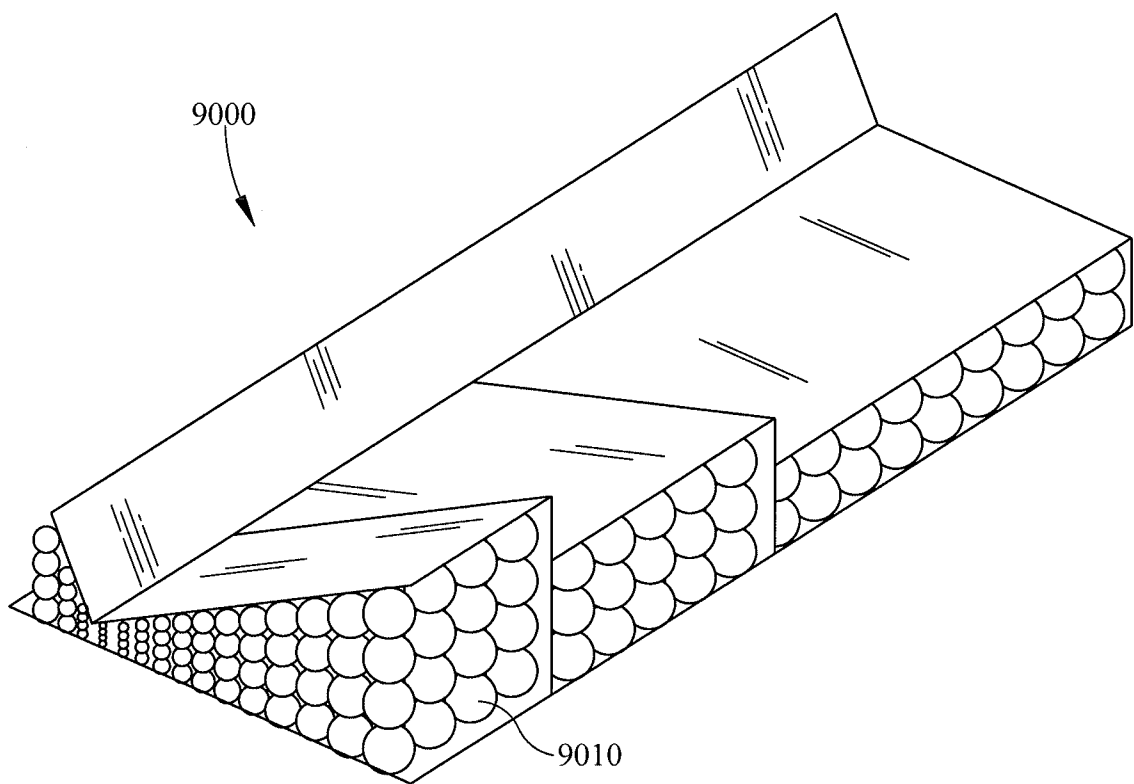


*FIG. 90*

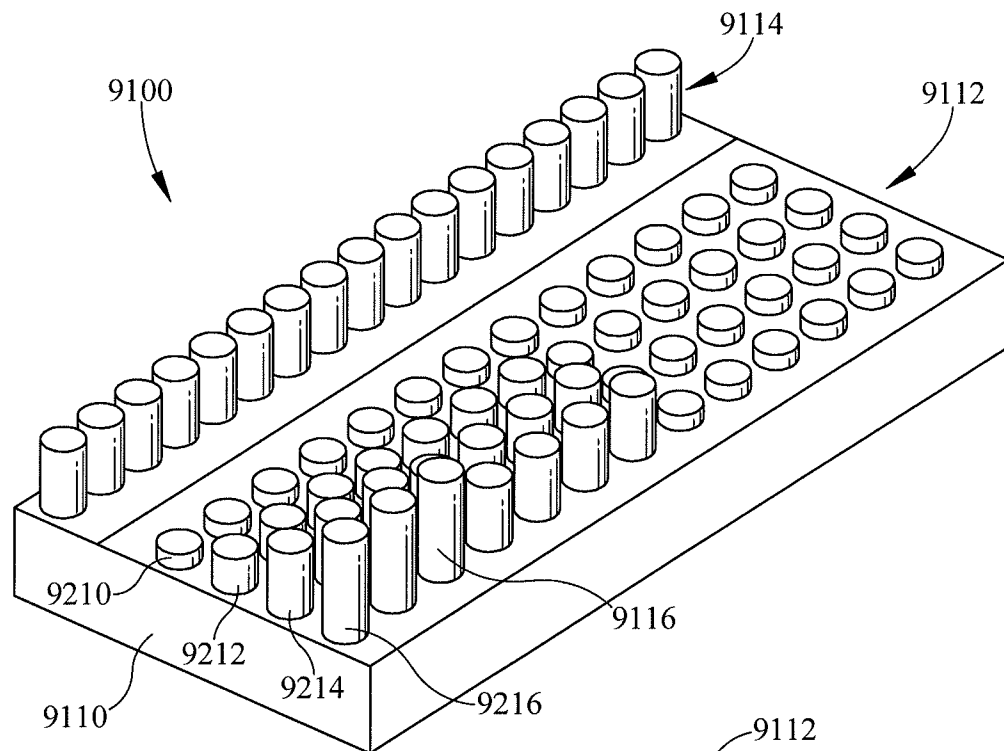


FIG. 91

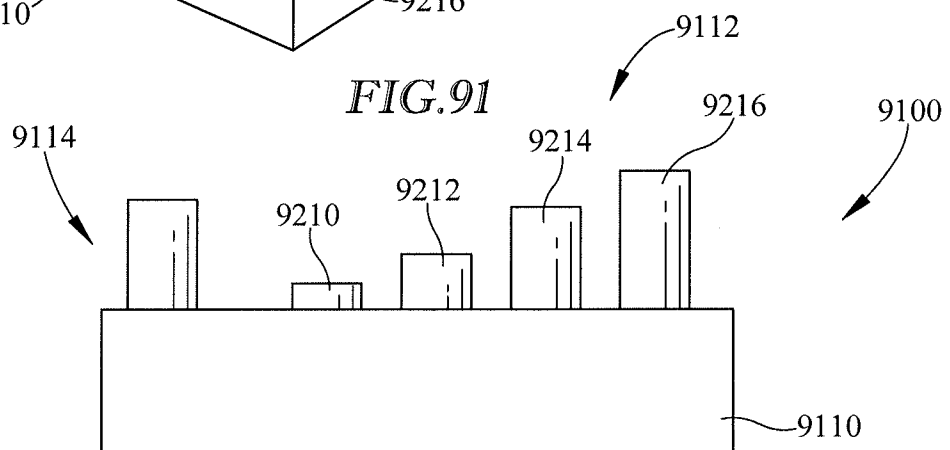


FIG. 92

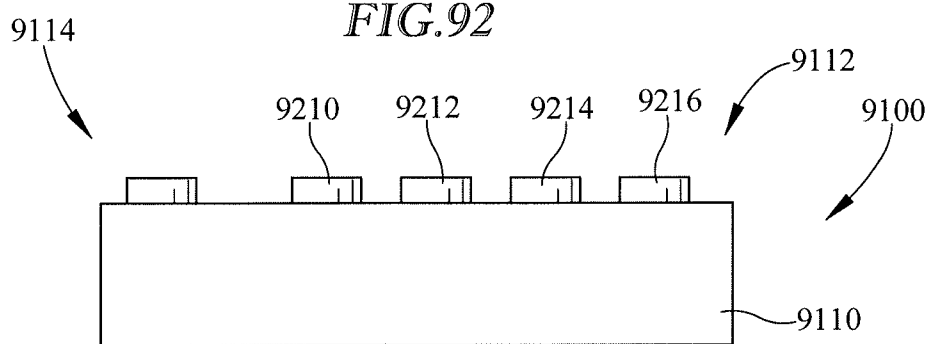


FIG. 93

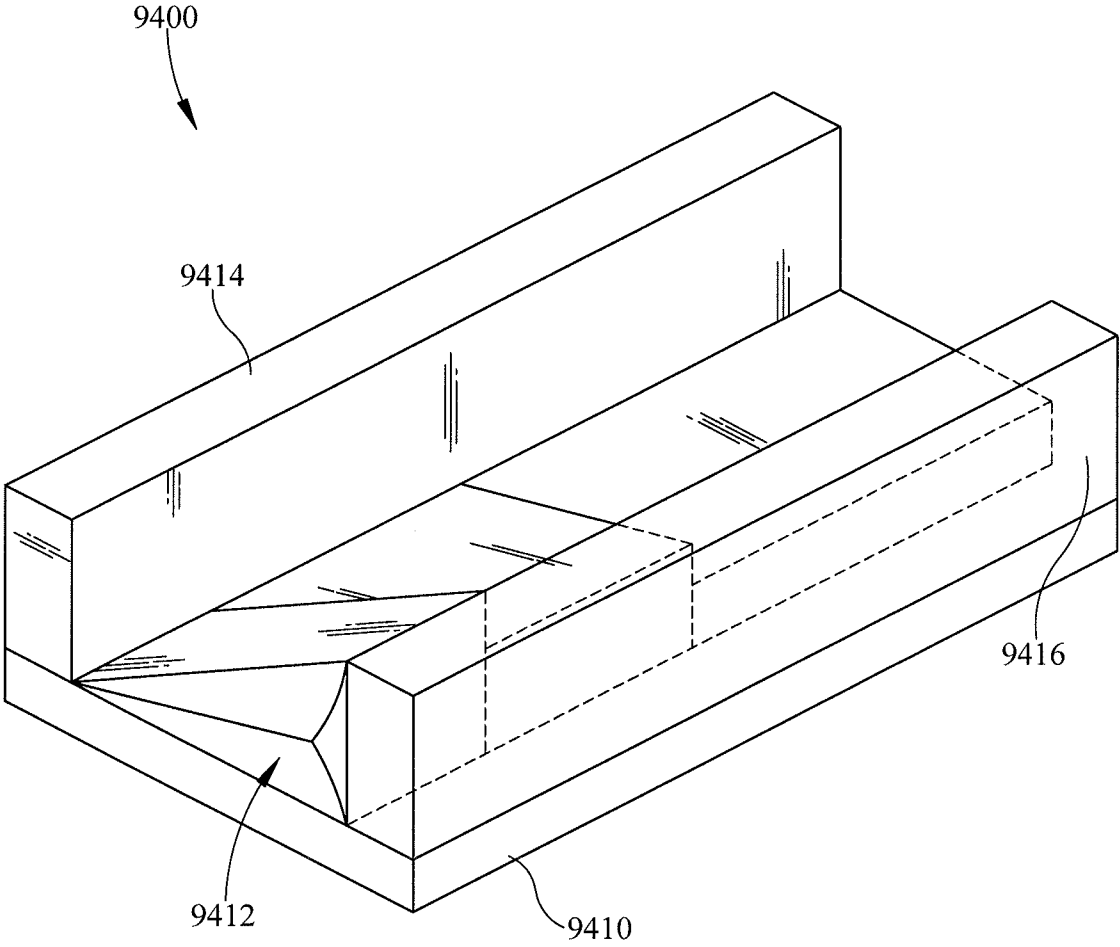


FIG.94

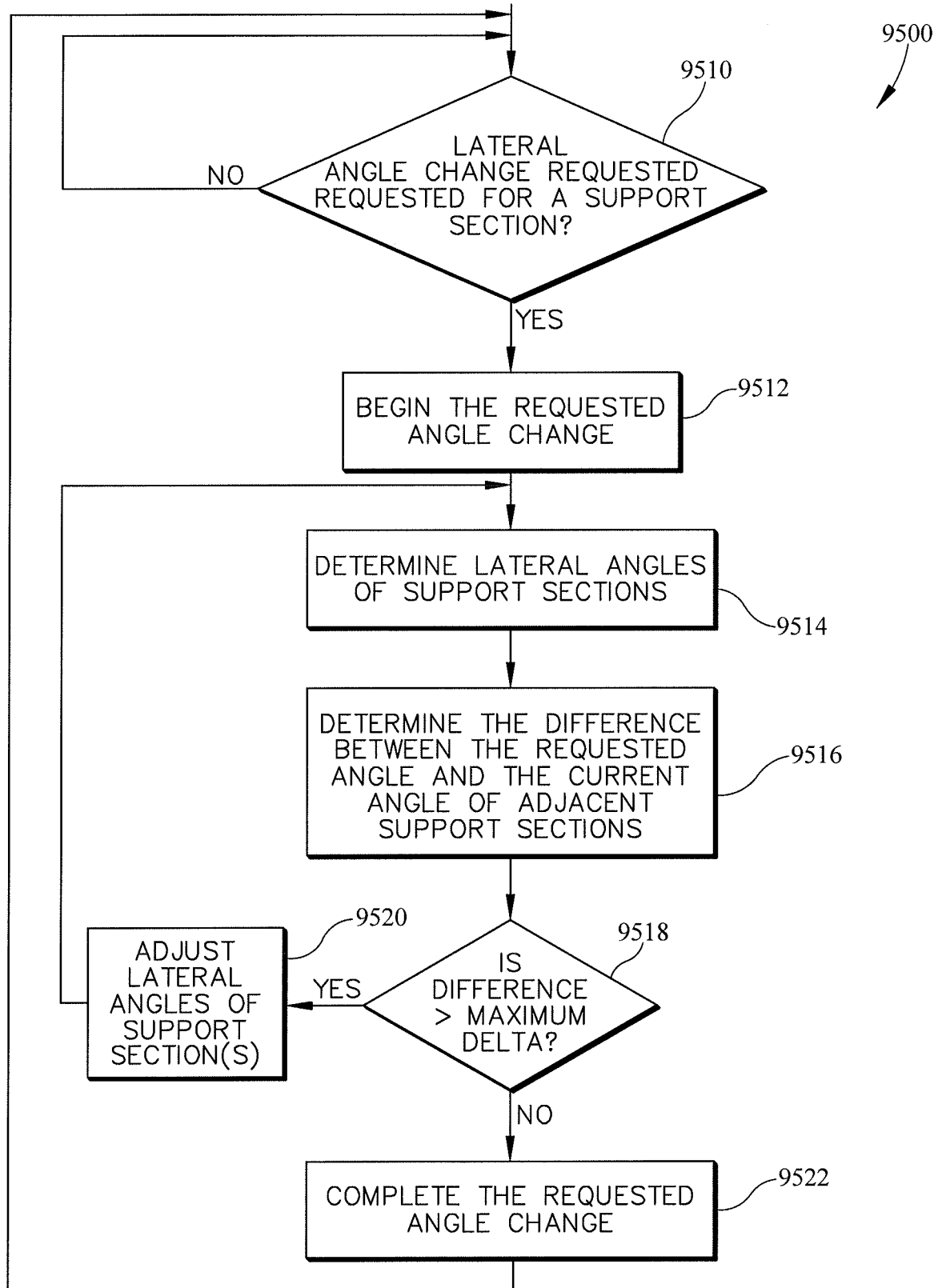


FIG. 95

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US14/18033

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-18, 25-30, 36-38, 43-62, 72-80, 84-86, 90-101, 105-114, 118-120, 126-128, 133-144, 148-175, 179-180, 182-190, 196, 201-213, 218-225, 231-234, 239-243, 247-268  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

----Please See Supplemental Page----

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-2, 3/1, 3/2, 130-131, 132/130, 132/131

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US14/18033

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61G 7/015; G06Q 50/22 (2014.01)

USPC - 340/573.1; 601/84, 301

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classification(s): A61B 5/00, 5/11; A61G 7/015; G06F 19/00; G06Q 50/22; G08B 21/02 (2014.01)

USPC Classification(s): 5/600, 618, 620; 128/845; 340/573.1; 601/84, 301, 595; 700/275

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

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

MicroPatent (US Granted, US Applications, EP-A, EP-B, WO, JP, DE-G, DE-A, DE-T, DE-U, GB-A, FR-A); Google; Google Scholar; ProQuest; IP.com; keywords: caregiver, caretaker, nurse, patient, attendant, bed, support structure, table, bench, assess, diagnose, predict, protocol

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                          | Relevant to claim No.                    |
|-----------|-------------------------------------------------------------------------------------------------------------|------------------------------------------|
| X         | US 2011/0035057 A1 (RECEVEUR T J et al.) February 10, 2011; figures 1, 4; paragraphs [0032], [0033], [0041] | 1-2, 3/1, 3/2, 130-131, 132/130, 132/131 |
| A         | US 2011/0263950 A1 (LARSON B J et al.) October 27, 2011; entire document                                    | 1-2, 3/1, 3/2, 130-131, 132/130, 132/131 |
| A         | US 2011/0301440 A1 (RILEY C W et al.) December 08, 2011; entire document                                    | 1-2, 3/1, 3/2, 130-131, 132/130, 132/131 |
| A         | US 2012/0073054 A1 (O'KEEFE C R et al.) March 29, 2012; entire document                                     | 1-2, 3/1, 3/2, 130-131, 132/130, 132/131 |

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

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

22 July 2014 (22.07.2014)

Date of mailing of the international search report

15 AUG 2014

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents  
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Shane Thomas

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

\*\*\*\*-Continued from Box No. III: Observations where unity of invention is lacking-\*\*\*

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-3, 130-132 are directed toward communicating a proposed configuration of a person support structure corresponding to the care protocol for a caregiver to approve.

Group II: claims 19-21 are directed toward determining if an adverse event is in progress based on the input signal.

Group III: claims 22-24 are directed toward an occupant support surface.

Group IV: claims 31, 32 are directed toward receiving an input signal indicative of a second physiological characteristic of the person at a second time.

Group V: claims 33-35 are directed toward a sensor configured to sense the orientation of a person's head with respect to a reference plane.

Group VI: claim 39 are directed toward a plurality of support pieces defining a respective support plane having a lateral rotational angle.

Group VII: claims 40-42 are directed toward determining if an apnea event is in progress based on the input signal.

Group VIII: claims 63-67 are directed toward a garment including a fluid bladder.

Group IX: claims 68-71, 115-117 are directed toward an input device configured to receive information indicative of the sleep state of a person.

Group X: claims 81-83, 228-230 are directed toward receiving an input indicative of at least one of a person's medical history and an adverse event risk score.

Group XI: claims 87-89 are directed toward determining a risk of a sleep apnea event occurring based on the input.

Group XII: claims 102-104 are directed toward receiving an input indicative of a person's body position.

Group XIII: claims 121-125 are directed toward a bolster positioned at the base of the sloped surface, the bolster being configured to maintain the person on the sloped surface.

Group XIV: claim 129 are directed toward receiving an input indicative of a posture of a person.

Group XV: claims 145-147, 176-178, 181, 191-195 are directed toward a closed air system.

Group XVI: claims 197-200 are directed toward activating the control system to monitor the user's sleep activities and patterns as the user begins to sleep.

Group XVII: claims 214-217 are directed toward one or more processors configured to select an apnea setting.

Group XVIII: claims 226-227 are directed toward a posture garment.

Group XIX: claims 235-238 are directed toward determining if an adverse event is likely based on a trend indicated by the plurality of inputs.

Group XX: claims 244-246 are directed toward a person support apparatus, wherein the support surfaces of at least two of the support sections have different maximum lateral tilt angles.

\*\*\*\*-Please See Next Supplemental Page-\*\*\*

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The inventions listed as Groups I-XX do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons.

The special technical features of Group I include receiving an input indicative of a person's level of risk for developing an adverse condition; selecting a care protocol based on the input (which is not present in Groups II, III, V-XX); communicating a proposed configuration of a person support structure corresponding to the care protocol for a caregiver to approve; and upon approval by the caregiver (which is not present in Groups II-XX), configuring the person support structure in accordance with the care protocol (which is not present in Groups II, III, V-XX).

The special technical features of Group II include receiving an input signal indicative of a physiological characteristic (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX); determining if an adverse event is in progress based on the input signal; upon determining that an adverse event is in progress, initiating a first intervention to stop the adverse event; receiving a second input signal indicative of the physiological characteristic at a time after the first intervention is initiated; determining if the adverse event is still in progress; upon determining that the adverse event is still in progress, initiating a second intervention (which is not present in Groups I, III-XX).

The special technical features of Group III include a mattress ticking; and a mattress core enclosed by the mattress ticking and including an occupant facing surface and at least one fluid bladder configured to selectively protrude from the occupant facing surface to support a portion of at least one of the neck and the upper back of an occupant supported on the occupant support surface (which is not present in Groups I-II, IV-XX).

The special technical features of Group IV include receiving an input indicative of a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk (which is not present in Groups II, III, V-XX); receiving an input signal indicative of a first physiological characteristic (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX) of a person supported on a person support structure (which is not present in Groups I-III, VI, VIII-XX) at a first time; receiving an input signal indicative of a second physiological characteristic of the person at a second time; comparing the first physiological characteristic to the second physiological characteristic; if the difference between the first physiological characteristic and second physiological characteristic is outside a predetermined range (which is not present in Groups I-III, V-XX), configuring the person support structure as a function of the care protocol (which is not present in Groups II, III, V-XX).

The special technical features of Group V include a person support structure configured to support a person thereon (which is not present in Groups I-III, VI, VIII-XX); a sensor configured to sense the orientation of a person's head with respect to a reference plane; a control system configured to control a function of the person support structure in response to the input from the sensor to maintain the person's head within a range of orientations (which is not present in Groups I-IV, VI-XX).

The special technical features of Group VI include a plurality of support pieces, each support piece of the plurality of support pieces defining a respective support plane having a lateral rotational angle with respect to a base surface of the support piece, wherein a first support piece of the plurality of support pieces defines a first support plane having a lateral rotational angle different from the lateral rotational angles of the other support planes (which is not present in Groups I-V, VII-XX).

The special technical features of Group VII include receiving an input signal indicative of a physiological characteristic of a person (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX) supported on a person support structure (which is not present in Groups I-III, VI, VIII-XX); determining if an apnea event is in progress based on the input signal; if an apnea event is in progress, generating an intervention (which is not present in Groups I-VI, VIII-XX).

The special technical features of Group VIII include a garment including a fluid bladder; and at least one rotation bladder coupled to the garment and configured to be selectively inflated to rotate a portion of a person wearing the garment between a first orientation and a second orientation (which is not present in Groups I-VII, IX-XX).

The special technical features of Group IX include an input device configured to receive information indicative of the sleep state of a person; and a control system configured to determine the sleep state of the person based on the information received by the input and control a device as a function of the sleep state of a person (which is not present in Groups I-VIII, X-XX).

The special technical features of Group X include receiving an input indicative of at least one of a person's medical history and an adverse event risk score; determining if a sleep apnea event is likely based on the input (which is not present in Groups I-IX, XI-XX); and if a sleep apnea event is likely, generating an intervention (which is not present in Groups I-IX, XI-XVIII, XX).

The special technical features of Group XI include receiving an input indicative of a characteristic of a person (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX); determining a risk of a sleep apnea event occurring based on the input; and generating an intervention as a function of the risk that a sleep apnea event will occur (which is not present in Groups I-X, XII-XX).

The special technical features of Group XII include receiving an input indicative of a person's body position; receiving an input indicative of the person's medical condition; determining an effect that the person's position has on the medical condition; generating an intervention as a function of the effect (which is not present in Groups I-XI, XIII-XX).

The special technical features of Group XIII include a sloped surface; and a bolster positioned at the base of the sloped surface, the bolster being configured to maintain the person on the sloped surface (which is not present in Groups I-XII, XIV-XX).

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The special technical features of Group XIV include receiving an input indicative of a physiological characteristic of a person (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX) and a posture of a person; determining if an adverse event that is not a positional apnea event is in progress based on the input; if an adverse event is in progress, alerting a caregiver (which is not present in Groups I-XIII, XV-XX).

The special technical features of Group XV include a person support apparatus comprising a closed air system having at least one support piece configured to form a laterally angled sleep surface having a length defined between a first edge and an opposing second edge spaced from the first edge along a longitudinal axis of the support system, the at least one support piece comprising a pair of laterally-spaced fluid bladders communicatively coupled to each other; a computer having one or more processors in operational control communication with the person support apparatus; and a plurality of sleep sensors configured to sense user activity during sleep, each sleep sensor of the plurality of sleep sensors in signal communication with the one or more processors and configured to gather data and generate and transmit to the one or more processors signals indicative of the data gathered, each sleep sensor also configured to receive operation control signals from the one or more processors (which is not present in Groups I-XIV, XVI-XX).

The special technical features of Group XVI include activating the control system to monitor the user's sleep activities and patterns as the user begins to sleep; and activating the support system to rotate the user at a time during sleep (which is not present in Groups I-XV, XVII-XX).

The special technical features of Group XVII include a support system; and a control system operatively coupled to the support system, the control system having one or more processors configured to select an apnea setting for selecting one or more of the following: a number of support planes, dimensions of each support plane, and a desired lateral rotational angle and/or a desired longitudinal rotational angle at which one or more support planes are positioned to define the sleep surface (which is not present in Groups I-XVI, XVIII-XX).

The special technical features of Group XVIII include one or more select areas located on at least one of a front portion of the posture garment and a back portion of the posture garment including a material having a different elasticity than other areas of the posture garment to facilitate positioning the user in a desired direction to open the upper respiratory airway (which is not present in Groups I-XVII, XIX-XX).

The special technical features of Group XIX include receiving a plurality of inputs indicative of a characteristic of a person (which is not present in Groups I, III, V, VI, VIII-X, XII, XIII, XV-XVIII, XX); determining if an adverse event is likely based on a trend indicated by the plurality of inputs (which is not present in Groups I-XVIII, XX); and if a sleep apnea event is likely, generating an intervention (which is not present in Groups I-IX, XI-XVIII, XX).

The special technical features of Group XX include a plurality of support sections arranged along a length of the person support apparatus, each of the support sections having a support surface to support a body portion of the person and an inflatable portion supporting the support surface, the inflatable portion of the support section selectively inflatable and deflatable to position the support surface of the support section in a tilt position in which the support surface is angled at a maximum lateral tilt angle and position the support surface in a flat position in which the support surface is angled at a substantially flat angle, wherein the support surfaces of at least two of the support sections have different maximum lateral tilt angles (which is not present in Groups I-XIX).

The common technical features of Groups I-XX include receiving an input indicative of a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk; receiving an input signal indicative of a first physiological characteristic of a person supported on a person support structure; configuring the person support structure as a function of the care protocol, and if a sleep apnea event is likely, generating an intervention.

These common technical features are disclosed by US 2011/0035057 A1 (RECEVEUR): receiving an input indicative of a person's level of risk for developing an adverse condition; selecting a care protocol based on the level of risk (control system 12 collects (receiving) information (input) regarding (i.e. level of risk for developing an adverse condition) a patient 16 (person) who is the occupant of the bed 10; paragraph [0032]); receiving an input signal indicative of a first physiological characteristic of a person supported on a person support structure (control system 12 collects (receiving) information (input) and communicates to processor 20 which determines operational factors which include skin risk factor (i.e. first physiological characteristic) associated with risk of skin damage of patient 16 (person) on the bed 10 (person support structure); paragraphs [0032], [0041], [0050]); configuring the person support structure as a function of the care protocol (processor 20 processes the patient information collected by the receiver 18 and determines operational factors (care protocol) for the bed 10 (person support structure) and modifies operating parameters 88 which include limits (i.e. in accordance with the care protocol) on the operation of various functions (e.g. configuring the person support structure) of the bed 10 (person support structure); paragraph [0041]); and if a sleep apnea event is likely, generating an intervention (operational factors (care protocol) are modified (i.e. generating an intervention) based on risk factors such as fluid collection in the lungs (i.e. sleep apnea event) of a patient; paragraph [0050]).

Because the common technical features are disclosed by Receveur, the inventions are not so linked as to form a single general inventive concept. Therefore, Groups I-XX lack unity.