US 20240390203A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2024/0390203 A1
Dalbert et al. (43) Pub. Date: Nov. 28, 2024

(54) INTEGRATED PRESSURE SENSING AND REDISTRIBUTION FOR OPERATING TABLE PADS

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(21) Appl. No.: **18/671,450**

(22) Filed: **May 22, 2024**

Related U.S. Application Data

(60) Provisional application No. 63/468,069, filed on May 22, 2023, provisional application No. 63/468,068, filed on May 22, 2023.

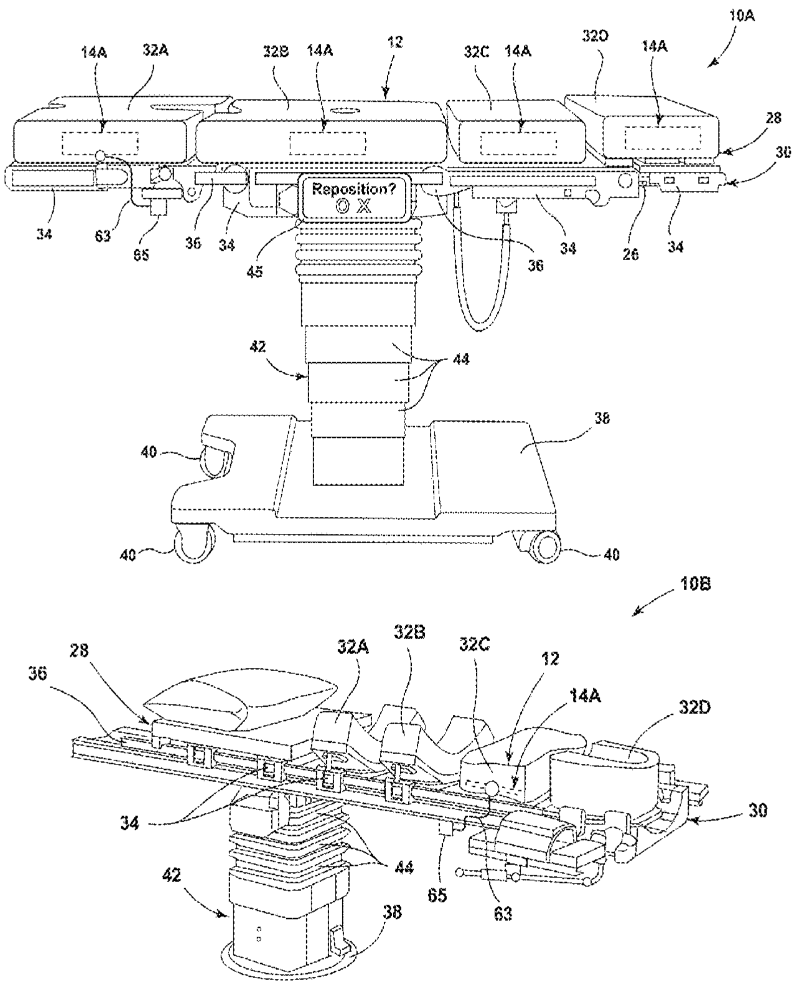
Publication Classification

(51) **Int. Cl.**
A61G 7/057 (2006.01)
G01L 1/18 (2006.01)

(52) **U.S. Cl.**
CPC *A61G 7/05769* (2013.01); *A61G 2203/10* (2013.01); *A61G 2203/34* (2013.01); *A61G 2210/50* (2013.01); *G01L 1/18* (2013.01)

(57) **ABSTRACT**

A patient table includes a patient support surface for supporting a patient and a pressure redistribution assembly that includes a pressure sensing assembly and a repositioning assembly. The pressure sensing assembly measures a pressure between the patient support surface and a patient at a plurality of sensing regions. The repositioning assembly includes a plurality of inflatable cells overlapping the plurality of sensing regions. A medium is located within the inflatable cells and an actuator selectively redistributes a quantity of the medium between the inflatable cells. A processor is configured to receive a measurement of the pressure from the pressure sensing assembly, determine if the measurement of pressure is above a threshold and, if the measurement of pressure is above the threshold, generate a signal to redistribute the medium.



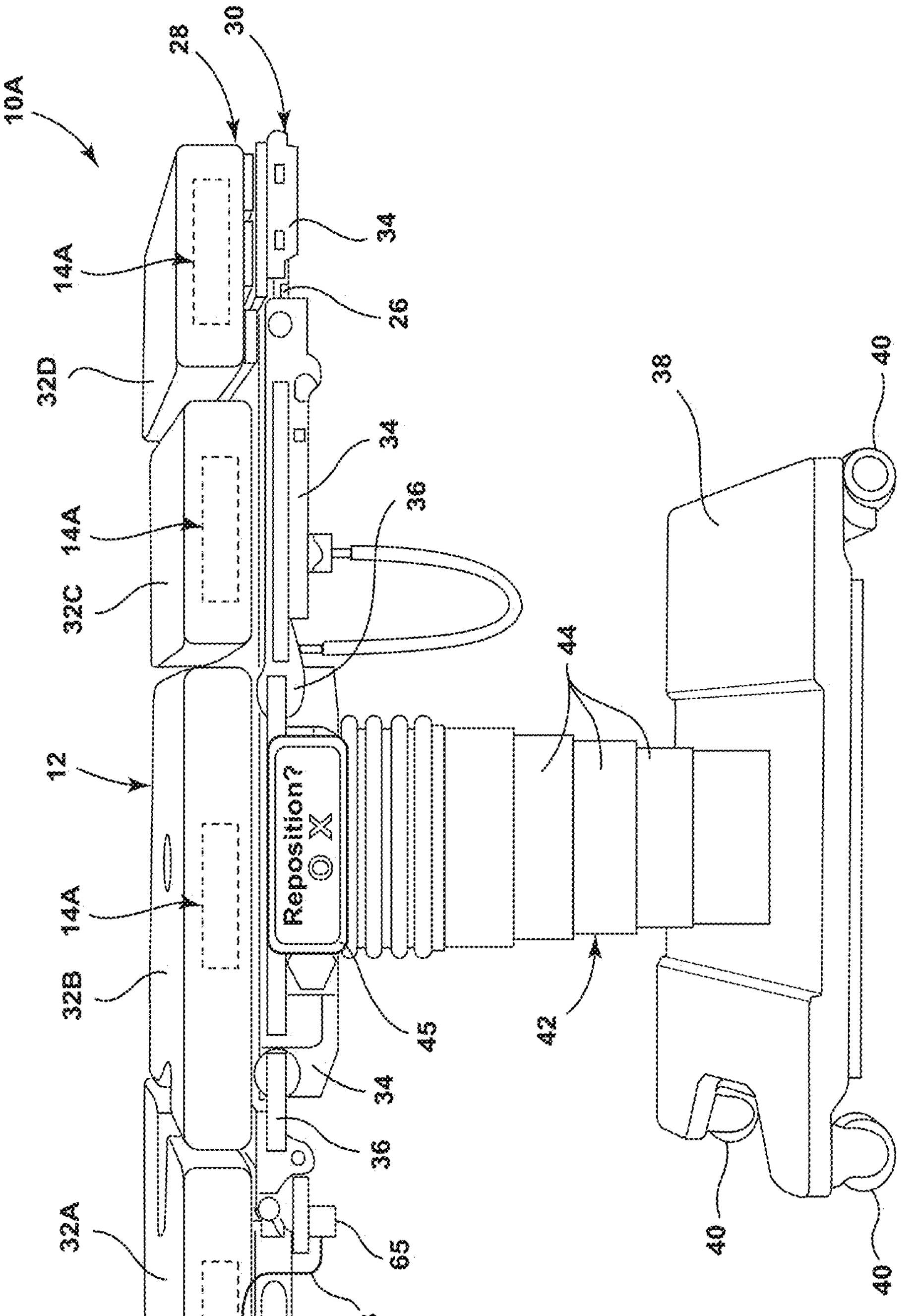

10A
28
30
14A
34
26
32D
34
36
14A
32C
38
40
44
12
Reposition?
14A
32B
45
42
34
36
32A
65
40
40
63
14A
34

FIG. 1A

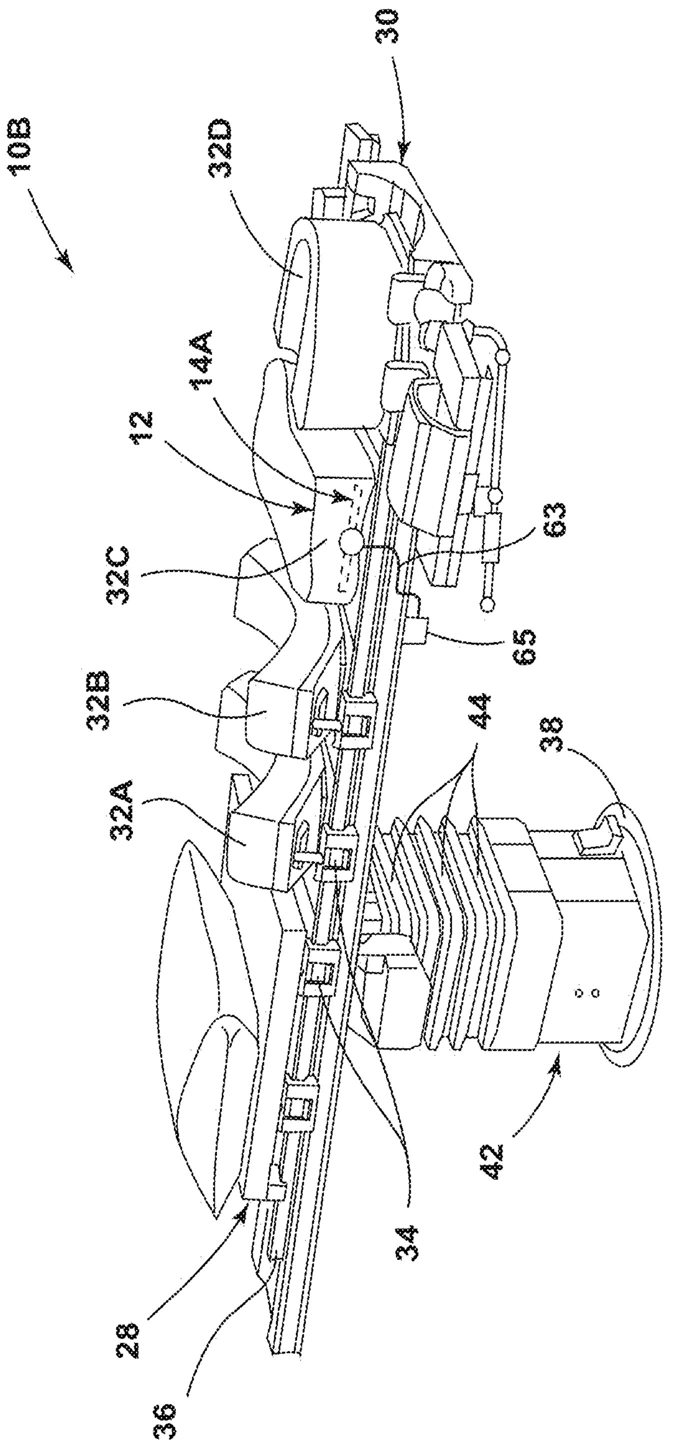


FIG. 1B

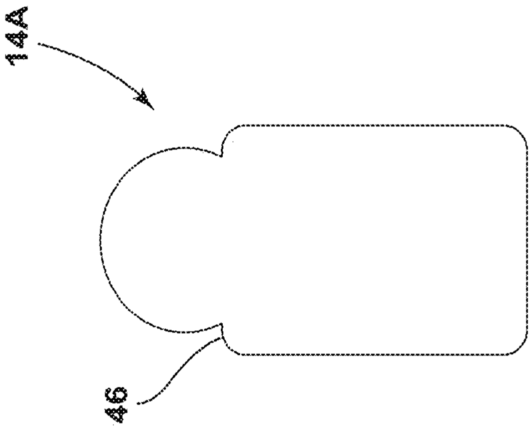


FIG. 2C

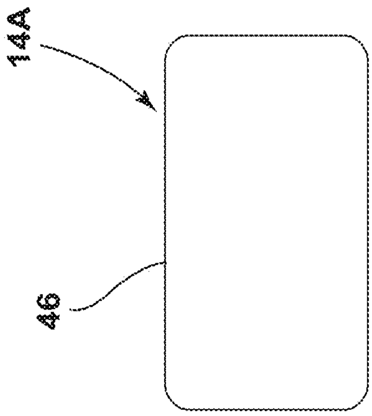


FIG. 2B

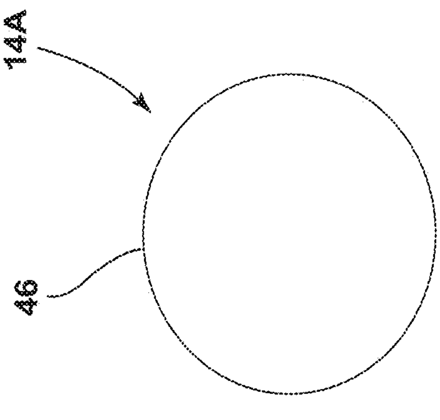


FIG. 2A

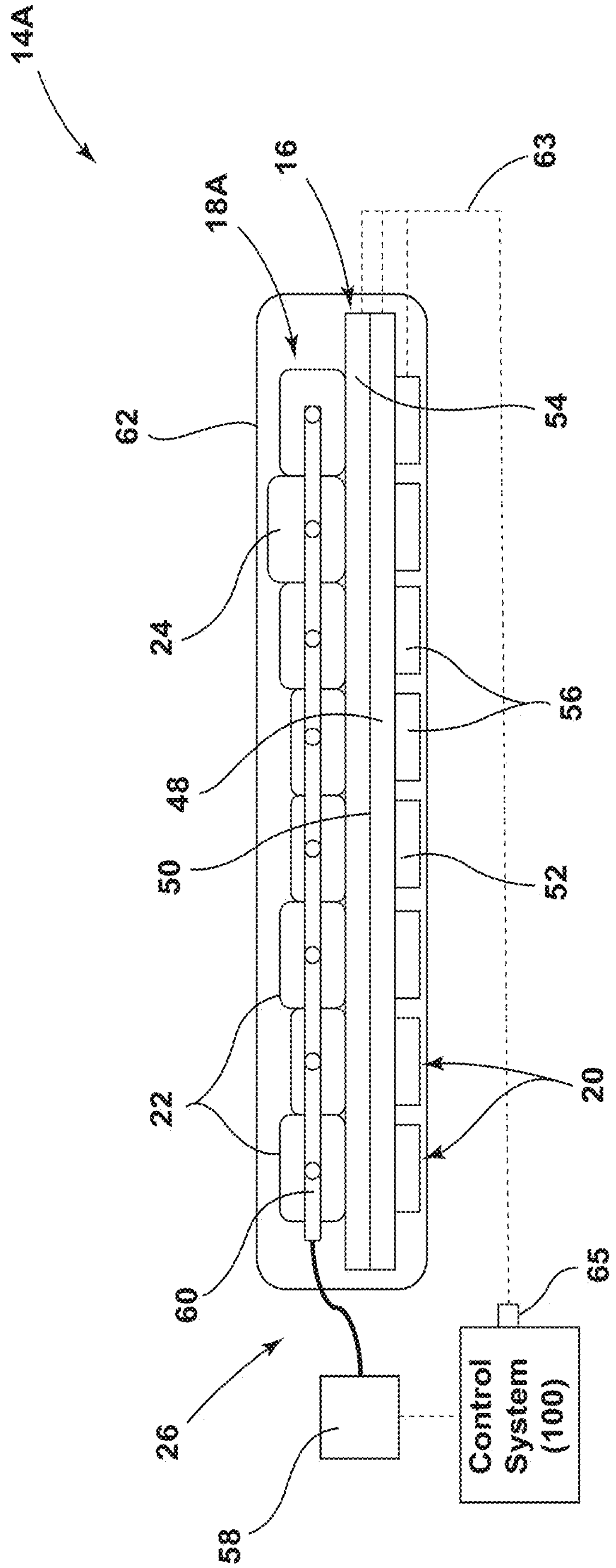

14A
18A
16
63
62
54
24
56
48
50
52
22
20
60
65
26
Control System (100)
58

FIG. 3A

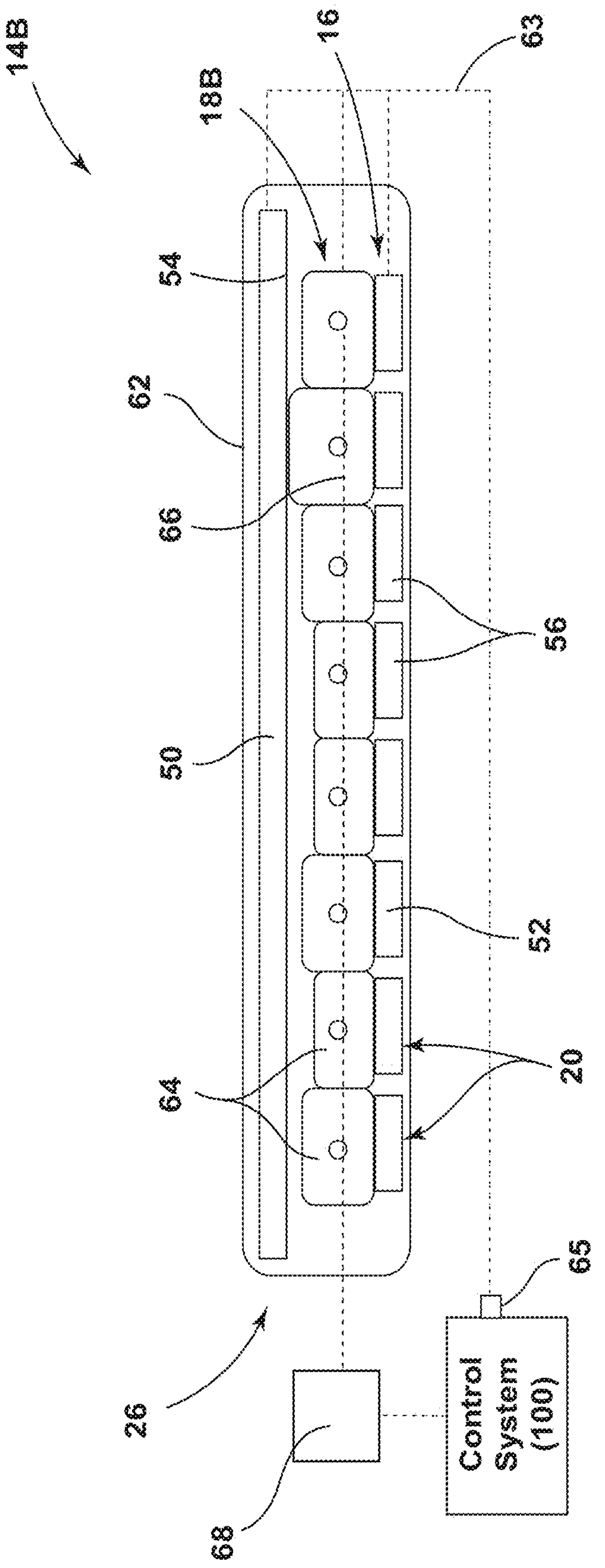


FIG. 3B

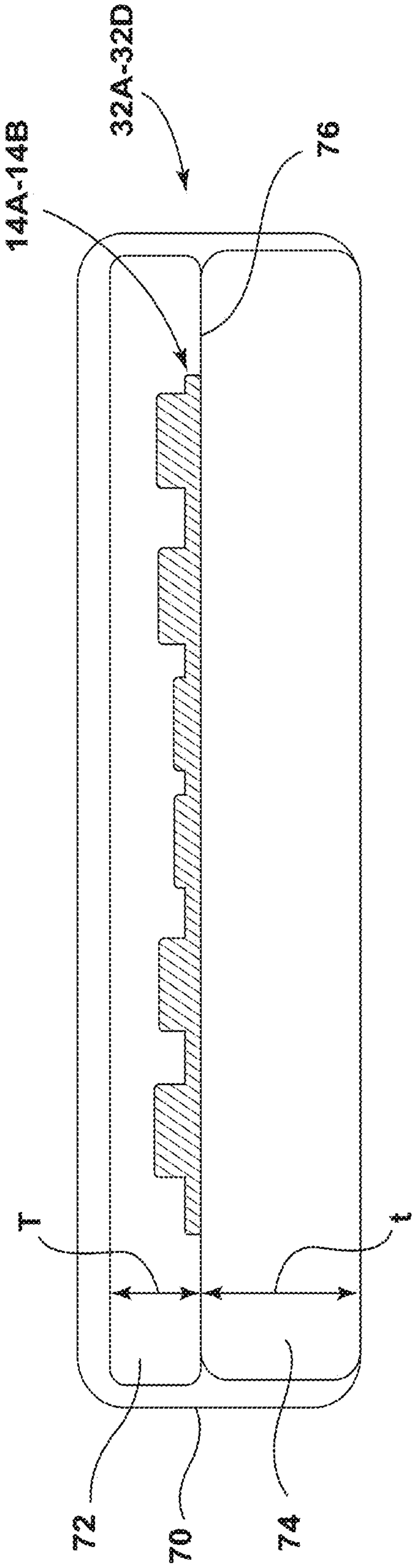


FIG. 4A

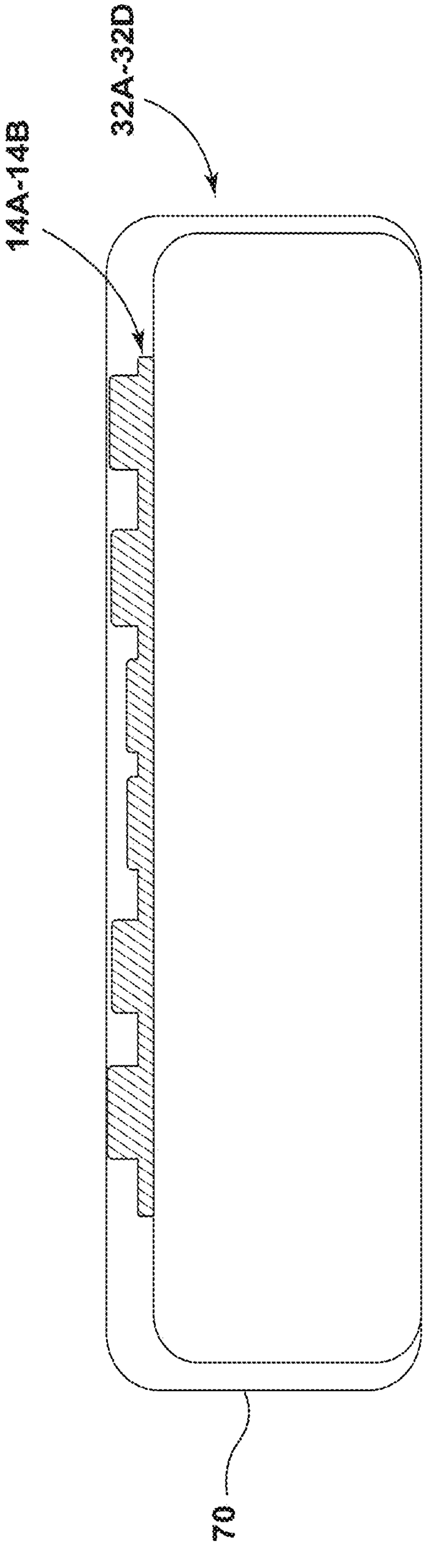


FIG. 4B

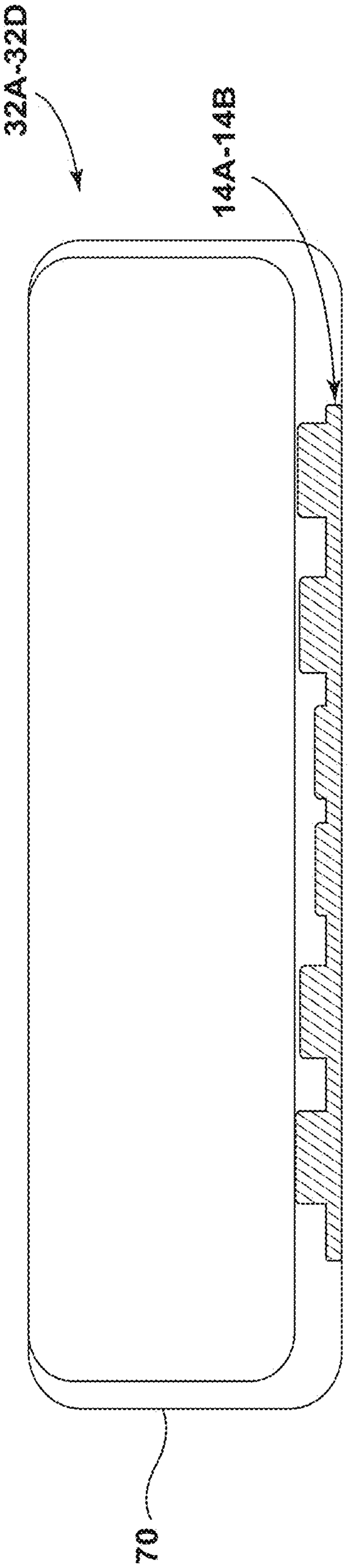


FIG. 4C

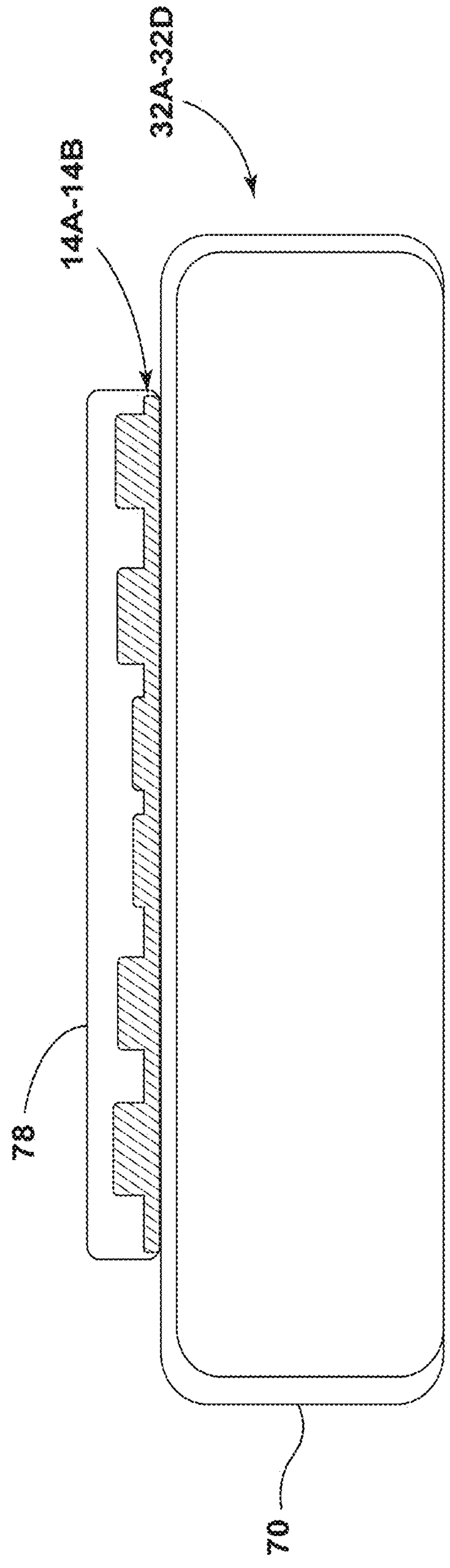


FIG. 4D

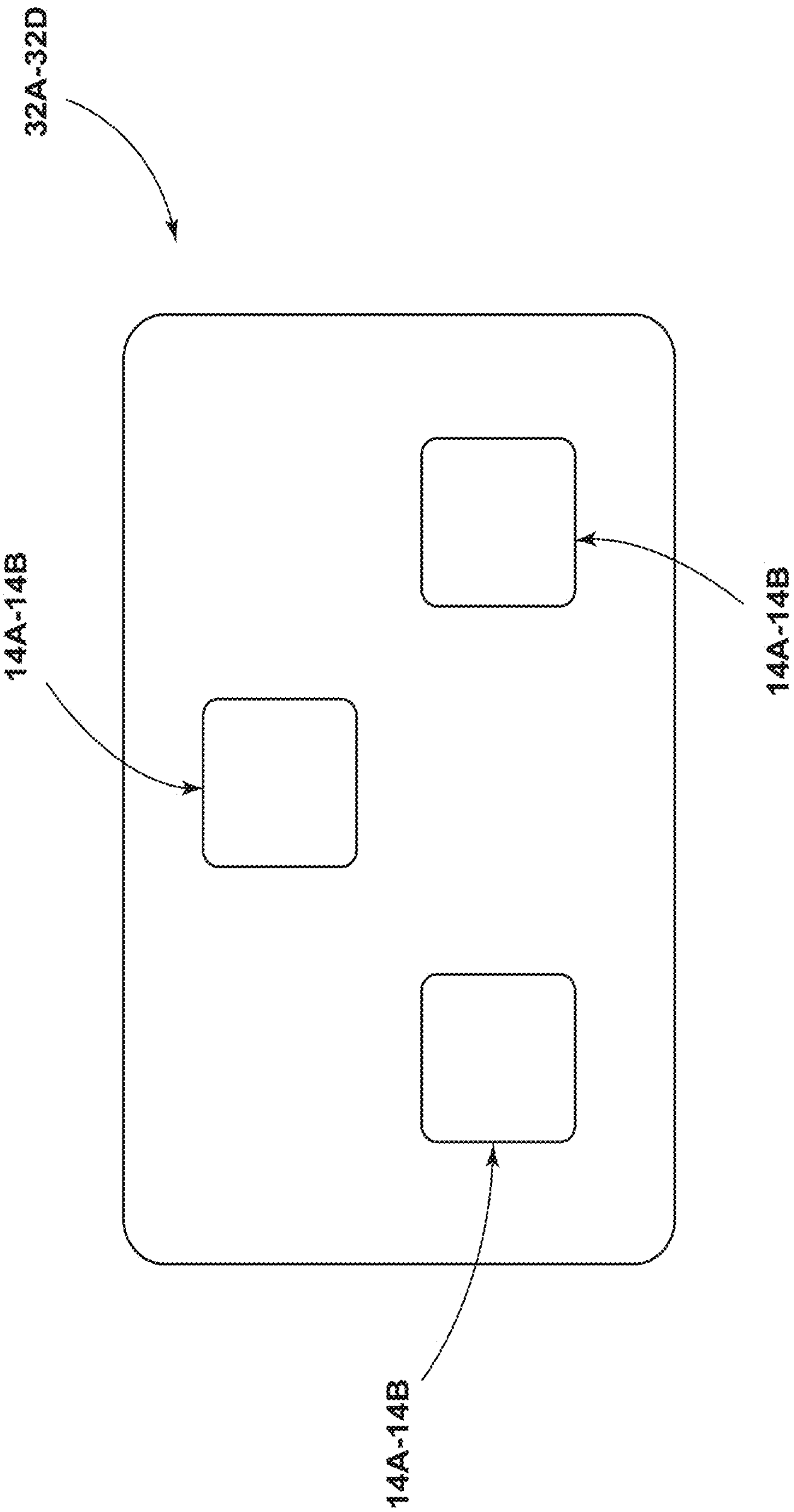


FIG. 5A

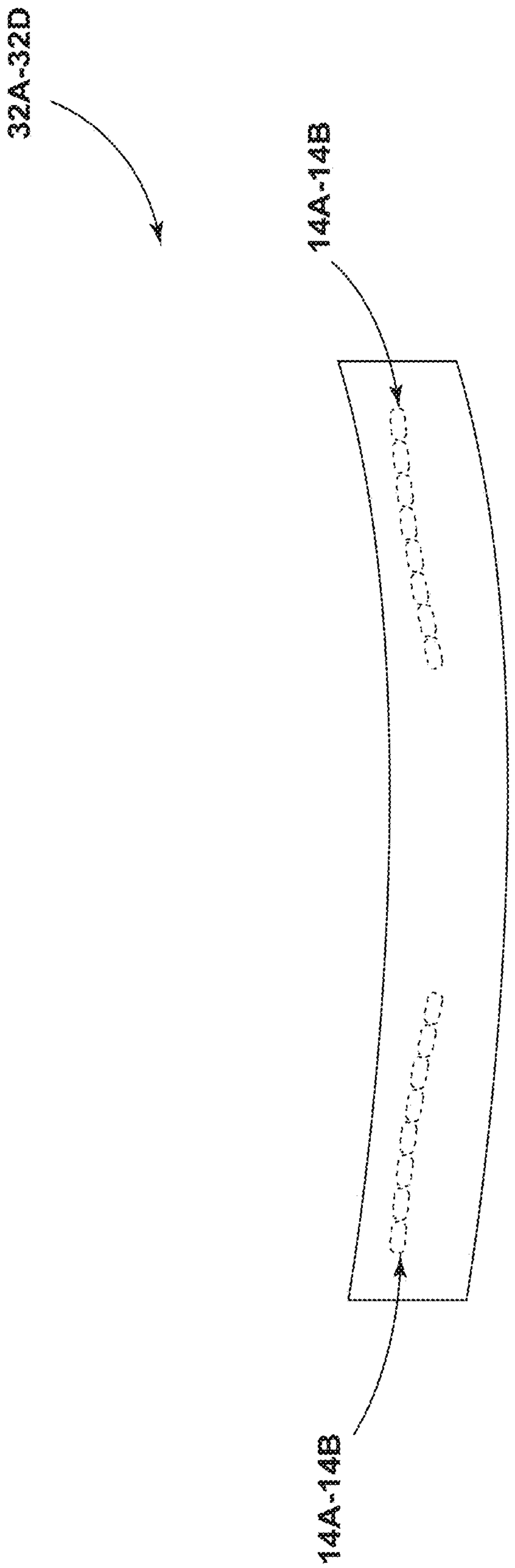


FIG. 5B

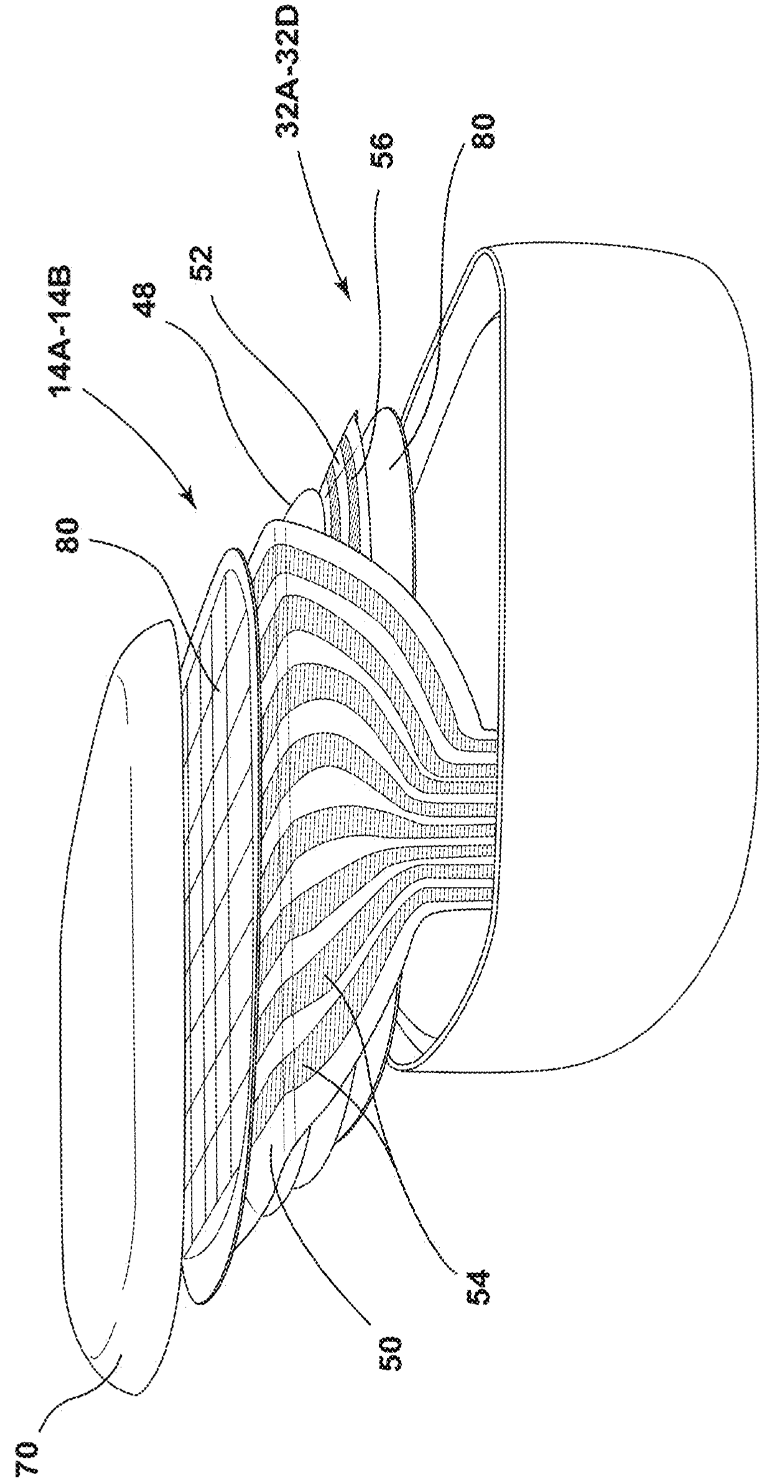


FIG. 6

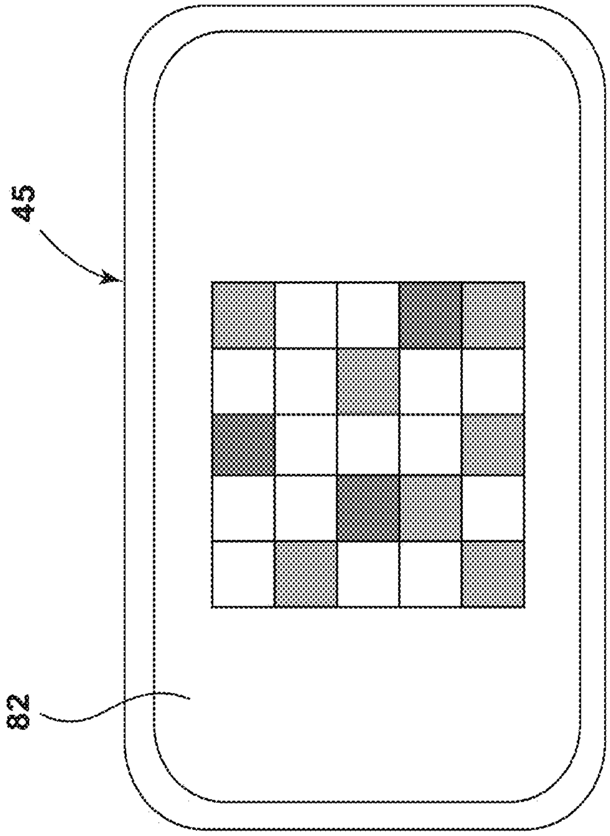


FIG. 7B

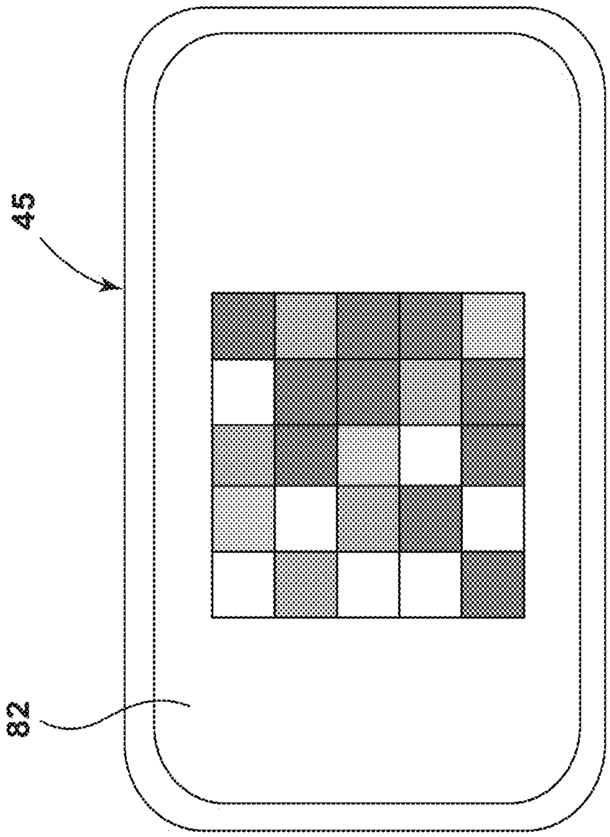


FIG. 7A

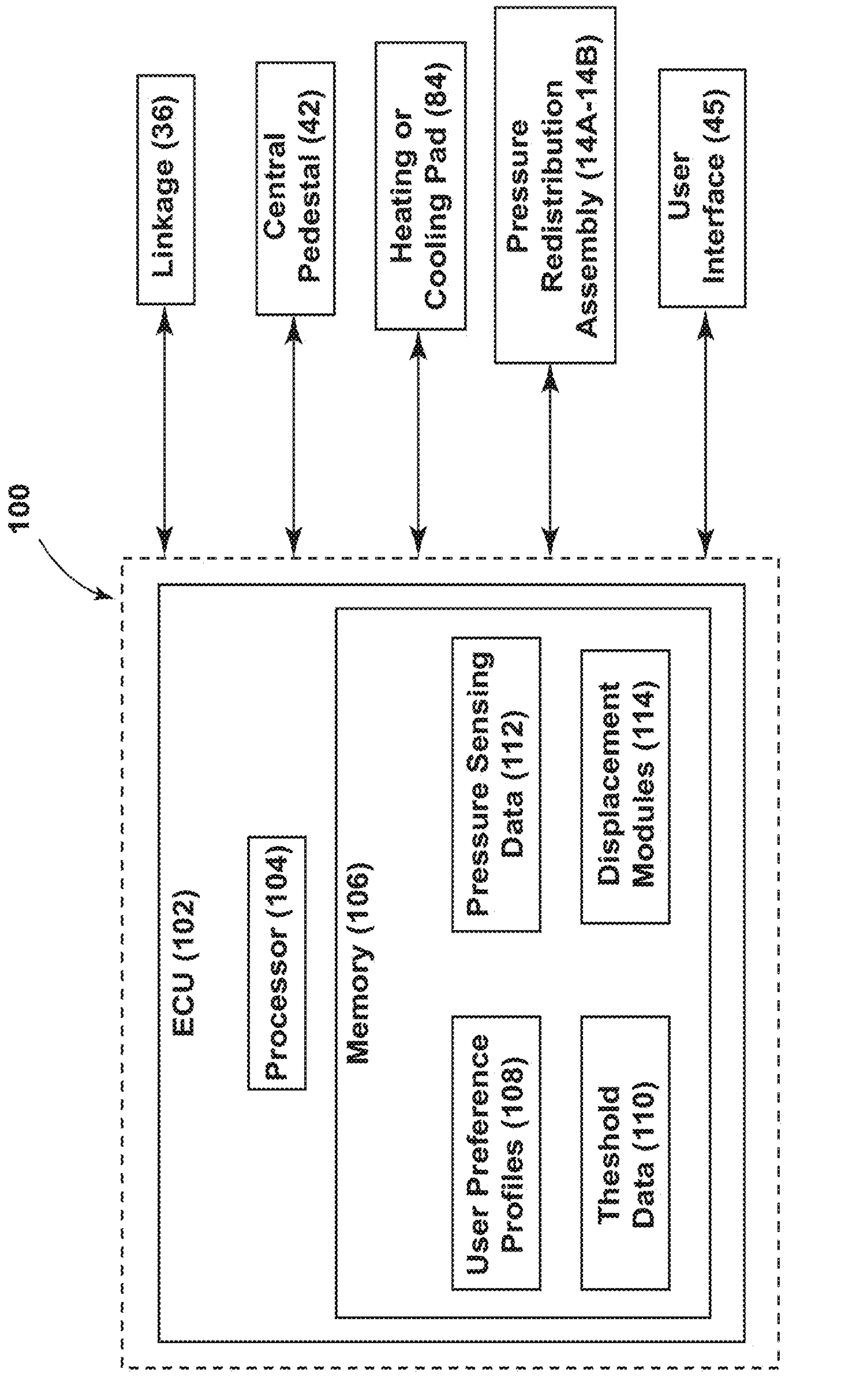

100
ECU (102)
Processor (104)
Memory (106)
User Preference Profiles (108)
Theshold Data (110)
Pressure Sensing Data (112)
Displacement Modules (114)
Linkage (36)
Central Pedestal (42)
Heating or Cooling Pad (84)
Pressure Redistribution Assembly (14A-14B)
User Interface (45)

FIG. 8

INTEGRATED PRESSURE SENSING AND REDISTRIBUTION FOR OPERATING TABLE PADS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under U.S.C. § 119 (e) to U.S. Provisional Application No. 63/468,069 filed on May 22, 2023, entitled "INTEGRATED PRESSURE SENSING AND REDISTRIBUTION FOR OPERATING TABLE PADS," and U.S. Provisional Application No. 63/468,068 filed on May 22, 2023, entitled "INTEGRATED PRESSURE SENSING AND REDISTRIBUTION FOR OPERATING TABLE PADS," the disclosures of which are hereby incorporated by reference in their entireties.

FIELD OF THE DISCLOSURE

[0002] The present disclosure generally relates to a pressure redistribution assembly and, more particularly, to a pressure redistribution assembly for a patient.

SUMMARY OF THE DISCLOSURE

[0003] According to one aspect of the present disclosure, a patient table includes a patient support surface for supporting a patient and at least one pressure redistribution assembly. Each of the at least one pressure redistribution assembly includes a pressure sensing assembly and a repositioning assembly. The pressure sensing assembly is located proximate to the patient support surface to measure a pressure between the patient support surface and a patient at a plurality of sensing regions. The repositioning assembly includes a plurality of inflatable cells overlapping the plurality of sensing regions. A medium is located within the inflatable cells, and an actuator selectively redistributes a quantity of the medium between the inflatable cells. A processor and a memory contains instructions that, when executed by the processor, cause the processor to receive a measurement of the pressure from the pressure sensing assembly. The processor is further caused to determine if the measurement of pressure is above a threshold and, if the measurement of pressure is above the threshold, generate a signal to redistribute the medium.

[0004] According to another aspect of the present disclosure, a pressure redistribution assembly for a patient includes a pressure sensing assembly and a repositioning assembly. The pressure sensor assembly includes a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers. Each conductive layer defines a plurality of conductive pathways that overlap to form a matrix of sensing regions. The repositioning assembly includes a plurality of inflatable cells overlapping the sensing regions, a medium located within the inflatable cells, and an actuator that selectively redistributes a quantity of the medium between the inflatable cells.

[0005] According to yet another aspect of the present disclosure, a cushion for a patient in an operating environment includes an outer envelope surrounding the cushion and a patient support surface is defined by a portion of the outer envelope. The cushion includes a pressure redistribution assembly located in the outer envelope. The pressure redistribution assembly includes a pressure sensing assembly and a repositioning assembly. The pressure sensing assembly includes a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers. Each conductive layer defines a plurality of conductive pathways that overlap to form a matrix of sensing regions. The repositioning assembly includes a plurality of piezo-electric actuators overlapping the sensing regions that expand and contract from an applied voltage.

[0006] These and other features, advantages, and objects of the present disclosure will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the drawings:

[0008] FIG. **1**A is a front perspective view of a first patient table including a pressure redistribution assembly according to an aspect of the present disclosure;

[0009] FIG. **1**B is a front perspective view of a second patient table including a pressure redistribution assembly according to an aspect of the present disclosure;

[0010] FIG. **2**A is a top view of a pressure redistribution assembly having a first outer perimeter shape according to an aspect of the present disclosure;

[0011] FIG. **2**B is a top view of a pressure redistribution assembly having a second outer perimeter shape according to an aspect of the present disclosure;

[0012] FIG. **2**C is a top view of a pressure redistribution assembly having a third outer perimeter shape according to an aspect of the present disclosure;

[0013] FIG. **3**A is a cross-sectional view of a pressure redistribution assembly having a first construction according to an aspect of the present disclosure;

[0014] FIG. **3**B is a cross-sectional view of a pressure redistribution assembly having a second construction according to an aspect of the present disclosure;

[0015] FIG. **4**A is a cross-sectional view of a pressure redistribution assembly in a first location with respect to a cushion according to an aspect of the present disclosure;

[0016] FIG. **4**B is a cross-sectional view of a pressure redistribution assembly in a second location with respect to a cushion according to an aspect of the present disclosure;

[0017] FIG. **4**C is a cross-sectional view of a pressure redistribution assembly in a third location with respect to a cushion according to an aspect of the present disclosure;

[0018] FIG. **4**D is a cross-sectional view of a pressure redistribution assembly in a fourth location with respect to a cushion according to an aspect of the present disclosure;

[0019] FIG. **5**A is a top view of a cushion that includes a plurality of pressure redistribution assemblies according to an aspect of the present disclosure;

[0020] FIG. **5**B is a side view of a cushion that includes a plurality of pressure redistribution assemblies according to an aspect of the present disclosure;

[0021] FIG. **6** is a disassembled perspective view of a pressure redistribution assembly according to an aspect of the present disclosure;

[0022] FIG. **7**A is a front view of a display visualizing a first pressure distribution in a matrix pattern according to an aspect of the present disclosure;

[0023] FIG. **7**B is a front view of a display visualizing a second pressure distribution in a matrix pattern according to an aspect of the present disclosure; and

[0024] FIG. **8** is a schematic view of a control system according to an aspect of the present disclosure.

DETAILED DESCRIPTION

[0025] The present illustrated embodiments reside primarily in combinations of method steps and apparatus components related to a pressure redistribution assembly for a patient. Accordingly, the apparatus components and method steps have been represented, where appropriate, by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present disclosure so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein. Further, like numerals in the description and drawings represent like elements.

[0026] For purposes of description herein, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof, shall relate to the disclosure as oriented in FIG. **1**A. Unless stated otherwise, the term “front” shall refer to a surface closest to an intended viewer, and the term “rear” shall refer to a surface furthest from the intended viewer. However, it is to be understood that the disclosure may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific structures and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0027] The terms “including,” “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by “comprises a . . . ” does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

[0028] Referring to FIGS. **1**A, **2**A-**3**A, reference numeral **10**A generally designates a patient table under a first arrangement. The patient table **10**A includes a patient support surface **12** for supporting a patient and at least one pressure redistribution assembly **14**A. Each of the at least one pressure redistribution assembly **14**A includes a pressure sensing assembly **16** and a repositioning assembly **18**A (FIG. **3**A). The pressure sensing assembly **16** is located proximate to the patient support surface **12** to measure a pressure between the patient support surface **12** and a patient at a plurality of sensing regions **20**. The repositioning assembly **18**A under a first construction may include a plurality of adjustable actuators (e.g., a plurality of inflatable cells **22**) overlapping (e.g., each aligned) with one of the plurality of sensing regions **20**. A medium **24** is located within the inflatable cells **22** and an actuator **26** selectively redistributes a quantity of the medium **24** between the inflatable cells **22**. A control system **100** (FIG. **8**) includes a processor **104** and a memory **106** containing instructions that, when executed by the processor **104**, cause the processor **104** to receive a measurement of the pressure from the pressure sensing assembly **16**. The processor **104** is further caused to determine if the measurement of pressure is above a threshold and, if the measurement of pressure is above the threshold, generate a signal to redistribute the medium **24**.

[0029] With reference now to FIG. **1**A, the patient table **10**A includes a patient support mattress **28** and a mattress support frame **30** that supports and positions the patient support mattress **28**. In some embodiments, the patient support mattress **28** includes two or more (e.g., three, four, five, or six) cushions **32**A-**32**D and the mattress support frame **30** may include two or more sub-support frames **34** (e.g., three, four, five, or six). The sub-support frames **34** may be operably coupled by linkages **36** that permit articulation between adjacent sub-support frames **34** to position the cushions **32**A-**32**D and, by extension, the patient in varying orientations. The patient table **10**A further includes a base frame **38** that may include a plurality of caster wheels **40** that allow the patient table **10**A to roll between different locations in a medical facility (e.g., along an X-axis and a Z axis). A central pedestal **42** operably connects the base frame **38** to the mattress support frame **30**. The central pedestal **42** may be vertically (e.g., along a Y-axis) adjustable between a variety of positions to suit the needs of a caregiver. More particularly, the central pedestal **42** may include a series of telescopically adjustable sleeves **44**. In some embodiments, the central pedestal **42** connects centrally on the base frame **38** between the caster wheels **40** and centrally on the mattress support frame **30**, such that a patient’s center of mass is substantially aligned therewith. In some embodiments, a central wheel (not shown) may be located under the central pedestal **42** to facilitate movement around the medical facility. The central wheel may be driven via a motor, and/or the like, and moveable between an operating position and a stowed position. In some embodiments, the patient bed **10**A may include a user interface **45**, which may transmit and receive instructions or information about the pressure redistribution assembly **14**A and other components of the patient table **10**A. In some embodiments, the patient table **10**A may be configured as a patient operating table, such that it is used during therapy, surgery, and/or the like. However, it should be appreciated that, in other embodiments, the patient table **10**A may be configured as a long-term patient bed or resting surface.

[0030] With reference now to FIG. **1**B, a patient operating table **10**B under a second arrangement may be configured for spinal surgery. The patient operating table **10**B may include all the same features, functions, and materials as the patient operating table **10**A of the first arrangement. However, the patient operating table **10**B includes cushions **32**A-**32**D having a modified shape that alters the patient support surface **12**. More particularly, at least some of the cushions **32**A-**32**D may define an arch-shaped upper surface such that the patient support surface **12** effectively cradles the patient as the patient lays face forward towards the patient support surface **12**. Each or select of the cushions **32**A-**32**D may include at least one pressure redistribution assembly **14**A. In some embodiments, at least cushions **32**B-**32**D each include at least one pressure redistribution assembly **14**A. For example, the cushion **32**B may include a pair of pressure redistribution assemblies **14**A aligned with the patient’s hips, the cushion **32**C may include one or more pressure redistribution assemblies **14**A aligned with the patient’s chest, and the cushion **32**D may include one or more pressure redistribution assemblies **14**A aligned with the patient’s head (FIG. **5**B). In this manner, micro-adjustments of pressure redistribution assemblies **14**A reposition pressure on the patient's body without significant movement. Such, an arrangement may be particularly beneficial to spinal surgery applications as spinal surgery is oftentimes a time-intensive process where significant movement of the patient is not possible. In addition, some of the cushions **32**A-**32**D, such as cushion **32**B may be more narrow than the cushions **32**A-**32**D in the patient operating table **10**A of the first arrangement and thus a greater amount of pressure may be generated between the patient and the patient support surface **12**. Each or select ones of the cushions **32**A-**32**D may be located on sub-support frames **34** that are slidable on the support frame **30** with linkages **36** to adjust the cushions **32**A-**32**D to different sized patients.

[0031] With reference now to FIGS. **2**A-**2**C, the pressure redistribution assembly **14**A may include an outer perimeter **46** defining a surface area that the repositioning assembly **18**A can shift pressure between the patient and the patient support surface **12**. The outer perimeter **46** may have a variety of shapes. With reference to FIG. **2**A, the outer perimeter **46** may define one or more curves, such as a circular or oval shape. As such, the repositioning assembly **18**A can shift pressure between the patient and the patient support surface **12** within a circular or oval area. Such shapes may be beneficial for shifting pressure from limbs of the patient, shoulders, head, and/or the like. With reference now to FIG. **2**B, the outer perimeter **46** may define one or more straight edges, such as a rectangle or square. As such, the repositioning assembly **18**A can shift pressure between the patient and the patient support surface **12** within a rectangular, square, area of other shapes. Such shapes may be beneficial for shifting pressure from the limbs of the patient, torso, head, and/or the like. With reference now to FIG. **2**C, the outer perimeter **46** may define one or more portions of a human body. As such, the repositioning assembly **18**A can shift pressure between the patient and the patient support surface **12** within areas that match a body part of the patient, such as head, torso, limbs, or a combination thereof. Such shapes may be beneficial for shifting pressure for one or more specific regions of the body. In some embodiments, more than one repositioning assembly **14**A is located within the outer perimeter **46**.

[0032] With reference now to FIG. **3**A, the pressure redistribution assembly **14**A includes the repositioning assembly **18**A under the first construction. Under the first construction, as described previously, the repositioning assembly **18**A includes the plurality of inflatable cells **22** overlapping (e.g., each aligned) with one of the plurality of sensing regions **20**. The medium **24** is located within the inflatable cells **22**, and an actuator **26** selectively redistributes a quantity of the medium **24** between the inflatable cells **22**. The medium **24** may include air, liquid, or gel. The pressure sensing assembly **16** may include a piezo-resistive layer **48**, a top conductive layer **50**, and a bottom conductive layer **52**. The piezo-resistive layer **48** may be located between the top conductive layer **50** and the bottom conductive layer **52**. The top conductive layer **50** includes a plurality of rows of conductive pathways **54** (e.g., traces) and the bottom conductive layer **52** includes a plurality of columns of conductive pathways **56** (e.g., traces). The plurality of rows of conductive pathways **54** extend transverse to the plurality of columns of conductive pathways **56** and overlap to form the sensing regions **20**. The sensing regions **20** may, therefore, be arranged in a scalable, matrix-like pattern defined by the overlapping conductive pathways **54**, **56**. The plurality of rows of conductive pathways **54** may include five (5) or more rows and the plurality of columns of conductive pathways may include five or more columns defining at least twenty-five (25) sensing regions. In some embodiments, the number of rows may be equal to the number of columns. In some embodiments, the number of rows may be less than or equal to the number of columns. For example, the plurality of rows of conductive pathways **54** may include eight (8) or more rows and the plurality of columns of conductive pathways **56** may include eight (8) or more columns defining at least sixty-four (64) sensing regions **20**. In some embodiments, the plurality of rows of conductive pathways **54** extend perpendicularly to the plurality of columns of conductive pathways **56** and overlap to form the sensing regions **20**.

[0033] With continued reference to FIG. **3**A, the number of inflatable cells **22** may be equal or unequal to the number of the sensing regions **20**. For example, each of the sensing regions **20** may include a single one of the inflatable cells **22** aligned therewith. However, in some embodiments, the sensing regions **20** may not be aligned with the inflatable cells **22**, overlapping in alignment, overlapping in non-aligned relationship, overlapping in a staggered relationship, and/or the like. In this manner, the inflatable cells **22** can be specifically actuated based on the pressure between the patient support surface **12** and the patient at a particular sensing region **20**. The actuator **26** in the repositioning assembly **18**A may include a pump **58** and a manifold **60** of medium pathways. The medium pathways in the manifold **60** may be fluidically connected to each of the inflatable cells **22**. The manifold **60** (e.g., via the pump **58**) may be configured to add the medium **24** to each of the inflatable cells **22**. In some embodiments, the manifold **60** (e.g., via the pump **58**) may be further configured to remove the medium **24** from each of the inflatable cells **22**. In this manner, the actuator **26** can distribute and redistribute the medium **24** between each of the inflatable cells **22**. The pressure redistribution assembly **14**A may be entirely or partially located in an outer wrapper **62**. In some embodiments, the outer wrapper **62** may be hermetically sealed. For example, in some embodiments, the pressure sensing assembly **16** and the repositioning assembly **18**A may be located in the outer wrapper **62** and one or both of the actuator **26** and the control system **100** may be located outside of the outer wrapper **62**. As will be described in further detail below, in some embodiments, the control system **100** may be located in the outer wrapper **62** or, otherwise, proximate the outer wrapper **62** and issue commands only to the pressure redistribution assembly **14**A. In other embodiments, the control system **100** may be configured as a global control system that issues commands to more than one pressure redistribution assembly **14**A and other features of the patient table **10**A, **10**B. In some embodiments, the control system **100** (e.g., the global control system **100**) is coupled to (e.g., connected to, located in, located on) the patient table **10**A, **10**B and a power conduit **63** may extend through the outer wrapper **62** and be operably connected to the control system **100**. More particularly, the patient table **10**A, **10**B may include at least one outlet port **65** that connects the redistribution assembly **14**A (e.g., the power conduit **63**) to the control system **100** for the transmission of power and operation instructions. In some embodiments, the power conduit **63** is hermetically sealed (e.g., via a gasket, an adhesive, epoxy, and/or the like) to the outer wrapper **62**. In some embodiments, the at least one output port **65** may be configured to connect to a plurality of power conduits **63** of more than one redistribution assembly **14**A. In some embodiments, the at least one output port **65** may include a plurality of output ports **65** to connect to the power conduits **63** of more than one redistribution assembly **14**A.

[0034] With reference now to FIG. **3**B, a pressure redistribution assembly **14**B includes the repositioning assembly **18**B under a second construction. Under the second construction, the pressure redistribution assembly **14**B may include all the same features, structures, materials, and functionalities of the first construction. However, rather than including inflatable cells **22**, the repositioning assembly **18**B relies on a piezo-electric effect to reposition the pressure distribution. More particularly, the piezo-resistive layer **48** may include a plurality of piezo-electric actuators **64** located in the same general position as the inflatable cells **22** in the first construction. The piezo-electric actuators **64** may be configured to expand and contract with an applied voltage. An electrical circuit **66** may extend to a power supply **68** and/or directly to the control system **100**. The electrical circuit **66** may include the power conduit **63**. In some embodiments, the control system **100** (e.g., the global control system **100**) is coupled to (e.g., connected to, located in, located on) the patient table **10**A, **10**B and the power conduit **63** may extend through the outer wrapper **62** and be operably connected to the control system **100**. More particularly, the patient table **10**A, **10**B may include the at least one outlet port **65** that connects the redistribution assembly **14**B (e.g., the power conduit **63**) to the control system **100** for the transmission of power and operation instructions. In some embodiments, the power conduit **63** is hermetically sealed (e.g., via a gasket, an adhesive, epoxy, and/or the like) to the outer wrapper **62**. In some embodiments, the at least one output port **65** may be configured to connect to a plurality of power conduits **63** of more than one redistribution assembly **14**B. In some embodiments, the at least one output port **65** may include a plurality of output ports **65** to connect to the power conduits **63** of more than one redistribution assembly **14**B.

[0035] With reference to FIGS. **3**A and **3**B, it is contemplated that adjustable actuators other than the inflatable cells **22** and piezo-electric actuators **64** may be implemented in the redistribution assemblies **14**A, **14**B under the first or second constructions. The example, the adjustable actuators may incorporate any material or assembly that expands and contracts based on an applied voltage, pneumatic technologies, electromagnetic technologies, and/or the like. Likewise, it should be appreciated that the pressuring sensing assembly **16** may include any material or assembly that measures pressure imparted by a patient. For example, the pressure sensors **52** may be configured as strain sensors, capacitive sensors, and/or other types of pressure sensors.

[0036] With reference now to FIGS. **4**A-**4**D, the pressure redistribution assembly **14**A, **14**B may be proximate to each cushion **32**A-**32**D, such as the cushions **32**A-**32**D illustrated in FIGS. **1**A-**3**B. An outer envelope **70** (e.g., the outer wrapper **62**) may surround one or more cushions **32**A-**32**D. In some embodiments, the pressure redistribution assembly **14**A, **14**B may be located in the outer envelope **70**. However, it should be appreciated that, in other embodiments, the pressure redistribution assembly **14**A, **14**B may be located outside of the outer envelope **70**.

[0037] With reference now to FIG. **4**A, the cushion **32**A-**32**D may include an upper cushion layer **72** located proximate to the patient support surface **12** and a lower cushion layer **74** spaced from the patient support surface **12** by the upper cushion layer **72**. The pressure redistribution assembly **14**A, **14**B may be located between the upper cushion layer **72** and the lower cushion layer **74**. The upper cushion layer **72** may be adhered to the lower cushion layer **74** with an adhesion layer **76**. The upper cushion layer **72** may define a first thickness "T" and the lower cushion layer **74** may define a second thickness "t" that is greater than the first thickness T. In some embodiments, the pressure redistribution assembly **14**A, **14**B includes two or more pressure redistribution assemblies **14**A, **14**B located in the cushion **32**A-**32**D. In some embodiments, two or more of the cushions **32**A-**32**D of the patient table **10**A, **10**B include at least one of the pressure redistribution assembly **14**A, **14**B.

[0038] With reference now to FIG. **4**B, the pressure redistribution assembly **14**A, **14**B may be located on a top surface of the cushion **32**A, **32**D. For example, the pressure redistribution assembly **14**A, **14**B may be located between the top surface of the cushion **32**A, **32**D and the outer envelope **70**. With reference now to FIG. **4**C, the pressure redistribution assembly **14**A, **14**B may be located on a bottom surface of the cushion **32**A, **32**D. For example, the pressure redistribution assembly **14**A, **14**B may be located between the bottom surface of the cushion **32**A, **32**D and the outer envelope **70**.

[0039] With reference now to FIG. **4**C, the pressure redistribution assembly **14**A, **14**B may be located outside of the outer envelope **70**. For example, the pressure redistribution assembly **14**A, **14**B may be located in the outer wrapper **62** and be configured to move independently relative to the cushion **32**A, **32**D and other features of the patient table **10**A, **10**B. In this manner, the location and number of the one or more of the pressure redistribution assemblies **14**A, **14**B can be reconfigured based on patient or provider needs including locations other than the patient table **10**A, **10**B. In some embodiments, at least one pad **78** is located in the outer wrapper **62** over and/or under the pressure redistribution assembly **14**A, **14**B.

[0040] With reference now to FIGS. **5**A and **5**B, the cushions **32**A-**32**D, such as those described in reference to FIGS. **1**A-**4**D, may include a plurality of the pressure redistribution assemblies **14**A, **14**B. The pressure redistribution assemblies **14**A, **14**B may be located to match areas of risk in the patient body that are susceptible to circulation issues, bed sores, and/or the like. It should be appreciated that the cushions **32**A-**32**D and/or the pressure redistribution assembly **14**A, **14**B may be utilized in structures other than the patient table **10**A, **10**B. For example, patient tables other than the patient table **10**A, **10**B may utilize the cushions **32**A-**32**D and/or the pressure redistribution assembly **14**A, **14**B. The other patient tables may include patient tables that are configured to allow a patient to rest on their back, stomach, or sides. The other patient tables may be configured for long-term patient care (e.g., a hospital bed) or short-term care (e.g., a patient operating table). In some embodiments, a chair may utilize the cushions **32**A-**32**D and/or the pressure redistribution assembly **14**A, **14**B (e.g., for the back and/or seat). The cushion **32**A-**32**D in FIG. **5**B may have a similar configuration to the cushions **32**A, **32**B illustrated in FIG. **1**B and be configured to support a patient during spinal surgery. The pressure redistribution assemblies **14**A, **14**B may be located to support opposite sides of the patient's hips.

[0041] With reference now to FIG. **6**, the pressure redistribution assembly **14**A, **14**B is illustrated with the piezo-resistive layer **48**, the top conductive layer **50**, and the bottom conductive layer **52** in a disassembled state. In some embodiments, the plurality of rows of conductive pathways **54** and the plurality of columns of conductive pathways **56** may each define a closed conduction loop. The pressure redistribution assembly **14**A, **14**B may further include a pair of protective layers **80** located on opposite sides of the piezo-resistive layer **48**, the top conductive layer **50**, and the bottom conductive layer **52**. The components of the pressure redistribution assembly **14**A, **14**B may be semi-flexible. In this manner, the pressure redistribution assembly **14**A, **14**B may determine a pressure between two rigid surfaces, two non-rigid surfaces (e.g., memory foam or the body of the patient), or a rigid and a non-rigid surface. In addition to the sensing regions **20** arranged in a scalable, matrix-like pattern, each sensing region **20** may be individually scalable based on the overlapping surface area between the conduction layers **50**, **52**. In some embodiments, the area of the sensing regions **20** is less than 1 cm2, for example, about 0.5 cm by 0.5 cm. In some embodiments, the pressure redistribution assembly **14**A, **14**B is substantially radiolucent so as not to interfere with X-rays and other types of medical imaging systems. For example, the top conductive layer **50** and the bottom conductive layer **52** may be formed of stretchable fabric (e.g., woven) with the conductive pathways **54**, **56**. The piezo-resistive layer **48** may also be flexible and partially formed of one or more fabrics, such as, cotton, spandex, nylon, and/or the like, with sections of piezo-resistive material aligned with each sensing region **20**. The piezo-resistive material may be a transparent semiconductor material, such as a transparent oxide semiconductor ("TCO"). Each of the conductive pathways **54**, **56** may exhibit detectable changes when exposed to pressure from a patient (e.g., changes in resistivity, capacitance, and/or the like). Because the conductive pathways **54**, **56** overlap into the matrix-like pattern, the detection in sensing regions **20** can be extrapolated via the control system **100** by detecting and corresponding the changes in the conductive pathways **54**, **56** to specific overlapped regions (e.g., the sensing regions **20**).

[0042] With reference now to FIGS. **7**A and **7**B, the user interface **45** may transmit and receive instructions or information about the pressure redistribution assembly **14**A, **14**B and other components of the patient table **10**A, **10**B. For example, the user interface **45** may include a display **82** that visualizes the pressure distribution across the matrix of sensing regions **20**. The user interface **45** may include various user inputs, such as buttons, touch screen, remotes, and/or the like. As such, the user interface **45** may be configured to transmit a signal to the actuator **26** via inputs from the user inputs. However, in some scenarios, the control system **100** may automatically generate a signal to the actuator **26** without requiring manual user inputs. In some embodiments, the visualization of the pressure distribution may be generated based on a predetermined threshold, such as a magnitude of pressure threshold or a period of time that the measurement of pressure is above the magnitude of pressure threshold. In some embodiments, the display **82** is configured as a touch screen allowing the provider or patient to adjust the pressure distribution on a micro, per sensing region **20**, basis. For example, touching one of the generated sensing regions **20** may allow adjustment to the inflatable cell **22** or the piezo-electric actuators **64** associated with the sensing region **20**. The sensing regions **20** may be generated with various colors, tone, hues, intensities, numbers, and/or other indicia that notify the provider or patient of the sensed pressure from any particular sensing region **20**. In some embodiments, the user interface **45** may also command certain operations associated with the patient table **10**A, **10**B, for example, the linkages **36** that permit articulation between adjacent sub-support frames **34**, the telescopically adjustable central pedestal **42**, and/or the like. In some embodiments, a heating or cooling pad **84** (FIG. **8**) may be aligned with the pressure redistribution assembly **14**A, **14**B and modify a temperature of the support surface **12** to encourage circulation or comfort of the patient based on the sensed pressure.

[0043] With reference to FIG. **8**, the control system **100** may include an electronic control unit (ECU) **102**. The ECU **102** may include a processor **104** and a memory **106**. The processor **104** may include any suitable processor **104**. Additionally, or alternatively, the ECU **102** may include any suitable number of processors, in addition to or other than the processor **104**. The memory **106** may comprise a single disk or a plurality of disks (e.g. hard drives) and includes a storage management module that manages one or more partitions within the memory **106**. In some embodiments, memory **106** may include flash memory, semiconductor (solid-state) memory, or the like. The memory **106** may include Random Access Memory (RAM), a Read-Only Memory (ROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), or a combination thereof. The memory **106** may include instructions that, when executed by the processor **104**, cause the processor **104** to, at least, perform the functions associated with the components of the patient operating table **10**A, **10**B and/or one or more of the pressure redistribution assembly **14**A, **14**B. For example, the linkages **36**, the telescopically adjustable central pedestal **42**, the user interface **45**, the heating or cooling pad **84**, and one or more of the pressure redistribution assembly **14**A, **14**B may, therefore, be controlled and/or receive instructions from the ECU **102**. The memory **106** may, therefore, include user preference profiles **108**, threshold data **110**, pressure sensing data **112**, and displacement models **114**. The control system **100** may be configured to issue global commands related to the patient table **10**A, **10**B or commands to only one or more of the pressure redistribution assembly **14**A, **14**B.

[0044] With reference to FIGS. **1**A-**8**, the weight control system **100** (e.g., the processor **104**) may be configured to perform the functions as described herein. For example, the control system **100** may be configured to receive a measurement of the pressure from the pressure sensing assembly **16**, determine if the measurement of pressure is above the threshold and, if the measurement of pressure is above the threshold, generate a signal (e.g., to the actuator **26**) to redistribute the medium **24** (or move the piezo-electric actuator **64**). More particularly, the control system **100** may receive pressure sensing data **112** from the pressuring sensing assembly **16**. The control system **100** may further determine if the measurement of pressure is above the threshold by comparing the pressure sensing data **112** to the threshold data **110**. The control system **100** may then generate a signal (e.g., to the actuator **26**) to redistribute the medium **24** (or move the piezo-electric actuator **64**) in accordance with the displacement models **114** and/or other learning algorithms. The user preference profiles **108** may include changing the threshold limits in accordance with specific patient needs. For example, an elderly patient may have a lower pressure tolerance before becoming uncomfortable. Likewise, if certain procedures are being performed, such as surgery, it may be beneficial to put limits on the speed and/or magnitude of the displacement from the repositioning assembly **18**A, **18**B. In some embodiments, the magnitude of the displacement from the repositioning assembly **18**A, **18**B is micro-level, such that the displacement encourages circulation and health without being particularly noticeable to a patient or provider.

[0045] With continued reference to FIGS. **1**A-**8**, the control system **100** (e.g., the processor **104**) may be configured to generate a warning if the measurement of pressure is above the threshold. For example, the control system **100** may generate an audible warning or a visual warning (e.g., on the display **82**). The visual warning may include the visualization of the pressure distribution across the matrix of sensing regions **20** with an option to manually control the redistribution. In some embodiments, the control system **100** may be configured to one of continually or periodically monitor the sensed pressure. In some embodiments, the control system **100** may generate a recommendation to reposition the patient before articulating the linkages **36** or the telescopically adjustable central pedestal **42**. It is contemplated that, in some embodiments, the pressure redistribution assembly **14**A, **14**B may not include the repositioning assembly **18**A, **18**B and instead rely on manual movement by a provider.

[0046] The invention disclosed herein is further summarized in the following paragraphs and is further characterized by combinations of any and all of the various aspects described therein.

[0047] According to one aspect of the present disclosure, a patient table includes a patient support surface for supporting a patient and at least one pressure redistribution assembly. Each of the at least one pressure redistribution assemblies includes a pressure sensing assembly and a repositioning assembly. The pressure sensing assembly is located proximate to the patient support surface to measure a pressure between the patient support surface and a patient at a plurality of sensing regions. The repositioning assembly includes a plurality of inflatable cells overlapping the plurality of sensing regions. A medium is located within the inflatable cells and an actuator selectively redistributes a quantity of the medium between the inflatable cells. A processor and a memory containing instructions, that when executed by the processor, cause the processor to receive a measurement of the pressure from the pressure sensing assembly. The processor is further caused to determine if the measurement of pressure is above a threshold and, if the measurement of pressure is above the threshold, generate a signal to redistribute the medium.

[0048] According to another aspect of the present disclosure, a pressure sensing assembly includes a piezo-resistive layer.

[0049] According to yet another aspect of the present disclosure, a pressure sensing assembly includes a top conductive layer and a bottom conductive layer.

[0050] According to still another aspect of the present disclosure, a piezo-resistive layer is located between a top conductive layer and a bottom conductive layer.

[0051] According to another aspect of the present disclosure, a top conductive layer includes a plurality of rows of conductive pathways and a bottom conductive layer includes a plurality of columns of conductive pathways.

[0052] According to yet another aspect of the present disclosure, a plurality of rows of conductive pathways extend transversely to a plurality of columns of conductive pathways and overlap to form sensing regions.

[0053] According to still another aspect of the present disclosure, a plurality of rows includes five or more rows of conductive pathways and a plurality of columns includes five or more columns of conductive pathways defining at least 25 sensing regions.

[0054] According to another aspect of the present disclosure, a plurality of rows includes eight rows of conductive pathways and a plurality of columns includes eight columns of conductive pathways defining at least 64 sensing regions.

[0055] According to yet another aspect of the present disclosure, a medium located within the inflatable cells includes one of air, liquid, or gel.

[0056] According to still another aspect of the present disclosure, a threshold includes a magnitude of pressure threshold.

[0057] According to yet another aspect of the present disclosure, a threshold further includes a period of time that the measurement of pressure is above a threshold.

[0058] According to still another aspect of the present disclosure, an output port and at least one cushion defines a patient support surface. The at least one pressure redistribution assembly is located in the cushion, and a power conduit operably connects the pressure redistribution assembly to the output port.

[0059] According to another aspect of the present disclosure, a threshold further includes a period of time that a measurement of pressure is above a magnitude of pressure threshold.

[0060] According to another aspect of the present disclosure, the at least one pressure redistribution assembly is substantially radiolucent.

[0061] According to yet another aspect of the present disclosure, a mattress defines the patient support surface.

[0062] According to still another aspect of the present disclosure, a mattress includes at least one cushion.

[0063] According to another aspect of the present disclosure, at least one pressure redistribution assembly is located within the at least one cushion.

[0064] According to yet another aspect of the present disclosure, at least one cushion includes an upper cushion layer that is located proximate to a patient support surface and a lower cushion layer that is spaced from a patient support surface by an upper cushion layer.

[0065] According to still another aspect of the present disclosure, at least one pressure redistribution assembly is located between an upper cushion layer and a lower cushion layer.

[0066] According to another aspect of the present disclosure, an upper cushion layer is adhered to a lower cushion layer with an adhesion layer.

[0067] According to yet another aspect of the present disclosure, an upper cushion layer defines a first thickness and a lower cushion layer defines a second thickness that is greater than the first thickness.

[0068] According to still another aspect of the present disclosure, at least one pressure redistribution assembly includes two or more pressure redistribution assemblies located in a cushion.

[0069] According to another aspect of the present disclosure, at least one cushion includes two or more cushions and at least one pressure redistribution assembly includes a pressure redistribution assembly located in each of the two or more cushions.

[0070] According to yet another aspect of the present disclosure, at least one pressure redistribution assembly is located on a top surface of a cushion.

[0071] According to still another aspect of the present disclosure, at least one pressure redistribution assembly includes a pad.

[0072] According to another aspect of the present disclosure, at least one pressure redistribution assembly is located on a bottom surface of a cushion.

[0073] According to another aspect of the present disclosure, a pressure redistribution assembly for a patient includes a pressure sensing assembly and a repositioning assembly. The pressure sensor assembly includes a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers. Each conductive layer defines a plurality of conductive pathways that overlap to form a matrix of sensing regions. The repositioning assembly includes a plurality of inflatable cells overlapping the sensing regions, a medium located within the inflatable cells, and an actuator that selectively redistributes a quantity of the medium between the inflatable cells.

[0074] According to yet another aspect of the present disclosure, a number of inflatable cells is equal to a number of sensing regions.

[0075] According to still another aspect of the present disclosure, each of the sensing regions includes a single one of the inflatable cells aligned therewith.

[0076] According to another aspect of the present disclosure, an actuator in a repositioning assembly includes a pump and a manifold of medium pathways.

[0077] According to another aspect of the present disclosure, a processor and a memory contain instructions that, when executed by the processor, cause the processor to receive a measurement of pressure from a pressure sensing assembly, determine if the measurement of pressure is above a threshold, and, if the measurement of pressure is above the threshold, generate a signal to redistribute the medium.

[0078] According to yet another aspect of the present disclosure, a cushion for a patient in an operating environment includes an outer envelope surrounding the cushion and a patient support surface is defined by a portion of the outer envelope. The cushion includes a pressure redistribution assembly located in the outer envelope. The pressure redistribution assembly includes a pressure sensing assembly and a repositioning assembly. The pressure sensing assembly includes a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers. Each conductive layer defines a plurality of conductive pathways that overlap to form a matrix of sensing regions. The repositioning assembly includes a plurality of piezo-electric actuators overlapping the sensing regions that expand and contract from an applied voltage.

[0079] According to still another aspect of the present disclosure, an upper cushion layer is located proximate to a patient support surface and a lower cushion layer is spaced from the patient support surface by the upper cushion layer.

[0080] According to another aspect of the present disclosure, a pressure redistribution assembly is located between an upper cushion layer and a lower cushion layer.

[0081] According to yet another aspect of the present disclosure, a pressure redistribution assembly is located along a top surface of a cushion.

[0082] According to still another aspect of the present disclosure, a pressure redistribution assembly is located along a bottom surface of the cushion.

[0083] According to yet another aspect of the present disclosure, a cushion has a power conduit extending through an envelope providing power to a pressure redistribution assembly.

[0084] It will be understood by one having ordinary skill in the art that construction of the described disclosure and other components is not limited to any specific material. Other exemplary embodiments of the disclosure disclosed herein may be formed from a wide variety of materials, unless described otherwise herein.

[0085] For purposes of this disclosure, the term "coupled" (in all of its forms, couple, coupling, coupled, etc.) generally means the joining of two components (electrical or mechanical) directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two components (electrical or mechanical) and any additional intermediate members being integrally formed as a single unitary body with one another or with the two components. Such joining may be permanent in nature or may be removable or releasable in nature unless otherwise stated.

[0086] As used herein, the term "about" means that amounts, sizes, formulations, parameters, and other quantities and characteristics are not and need not be exact, but may be approximate and/or larger or smaller, as desired, reflecting tolerances, conversion factors, rounding off, measurement error and the like, and other factors known to those of skill in the art. When the term "about" is used in describing a value or an end-point of a range, the disclosure should be understood to include the specific value or end-point referred to. Whether or not a numerical value or end-point of a range in the specification recites "about," the numerical value or end-point of a range is intended to include two embodiments: one modified by "about," and one not modified by "about." It will be further understood that the end-points of each of the ranges are significant both in relation to the other end-point, and independently of the other end-point.

[0087] The terms "substantial," "substantially," and variations thereof as used herein are intended to note that a described feature is equal or approximately equal to a value or description. For example, a "substantially planar" surface is intended to denote a surface that is planar or approximately planar. Moreover, "substantially" is intended to denote that two values are equal or approximately equal. In some embodiments, "substantially" may denote values within about 10% of each other, such as within about 5% of each other, or within about 2% of each other.

[0088] It is also important to note that the construction and arrangement of the elements of the disclosure, as shown in the exemplary embodiments, is illustrative only. Although only a few embodiments of the present innovations have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts, or elements shown as multiple parts may be integrally formed, the operation of the interfaces may be reversed or otherwise varied, the length or width of the structures and/or members or connectors or other elements of the system may be varied, and the nature or number of adjustment positions provided between the elements may be varied. It should be noted that the elements and/or assemblies of the system may be constructed from any of a wide variety of materials that provide sufficient strength or durability, in any of a wide variety of colors, textures, and combinations. Accordingly, all such modifications are intended to be included within the scope of the present innovations. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions, and arrangement of the desired and other exemplary embodiments without departing from the spirit of the present innovations.

[0089] It will be understood that any described processes or steps within described processes may be combined with other disclosed processes or steps to form structures within the scope of the present disclosure. The exemplary structures and processes disclosed herein are for illustrative purposes and are not to be construed as limiting.

What is claimed is:

1. A patient table comprising:

a patient support surface for supporting a patient; and

at least one pressure redistribution assembly, each of the at least one pressure redistribution assemblies comprising:

a pressure sensing assembly located proximate to the patient support surface to measure a pressure between the patient support surface and the patient at a plurality of sensing regions;

a repositioning assembly, the repositioning assembly including a plurality of inflatable cells overlapping the plurality of sensing regions, a medium located within the inflatable cells, and an actuator for selectively redistributing a quantity of the medium between the inflatable cells; and

a processor and a memory containing instructions that, when executed by the processor, cause the processor to:

receive a measurement of the pressure from the pressure sensing assembly;

determine if the measurement of pressure is above a threshold; and

if the measurement of pressure is above the threshold, generate a signal to redistribute the medium.

2. The patient table of claim **1**, wherein the pressure sensing assembly includes a piezo-resistive layer.

3. The patient table of claim **2**, wherein the pressure sensing assembly further includes a top conductive layer and a bottom conductive layer.

4. The patient table of claim **3**, wherein the piezo-resistive layer is located between the top conductive layer and the bottom conductive layer.

5. The patient table of claim **4**, wherein the top conductive layer includes a plurality of rows of conductive pathways and the bottom conductive layer includes a plurality of columns of conductive pathways.

6. The patient table of claim **5**, wherein the plurality of rows of conductive pathways extend transversely to the plurality of columns of conductive pathways and overlap to form the plurality of sensing regions.

7. The patient table of claim **6**, wherein the plurality of rows includes five or more rows of conductive pathways and the plurality of columns includes five or more columns of conductive pathways defining at least 25 sensing regions.

8. The patient table of claim **1**, wherein the medium located within the inflatable cells includes one of air, liquid, or gel.

9. The patient table of claim **1**, wherein the at least one pressure redistribution assembly is substantially radiolucent.

10. The patient table of claim **1**, wherein the threshold further includes a period of time that the measurement of pressure is above the threshold.

11. The patient table of claim **1**, further including an output port and at least one cushion defining the patient support surface, wherein the at least one pressure redistribution assembly is located in the cushion, and wherein a power conduit operably connects the pressure redistribution assembly to the output port.

12. A pressure redistribution assembly for a patient comprising:

a pressure sensing assembly including a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers, each conductive layer defining a plurality of conductive pathways that overlap to form a matrix of sensing regions; and

a repositioning assembly including a plurality of inflatable cells overlapping the sensing regions, a medium located within the inflatable cells, and an actuator for selectively redistributing a quantity of the medium between the inflatable cells.

13. The pressure redistribution assembly of claim **12**, wherein the number of inflatable cells is equal to the number of sensing regions.

14. The pressure redistribution assembly of claim **13**, wherein each of the sensing regions includes a single one of the inflatable cells aligned therewith.

15. A cushion for a patient in an operating environment comprising:

an outer envelope surrounding the cushion;

a patient support surface defined by a portion of the outer envelope; and

a pressure redistribution assembly located in the outer envelope and comprising:

a pressure sensing assembly including a pair of conductive layers and a piezo-resistive layer sandwiched between the pair of conductive layers, each conductive layer defining a plurality of conductive pathways that overlap to form a matrix of sensing regions; and

a repositioning assembly, the repositioning assembly including a plurality of piezo-electric actuators overlapping the sensing regions that expand and contract from an applied voltage.

16. The cushion of claim **15**, further including an upper cushion layer that is located proximate to the patient support surface and a lower cushion layer that is spaced from the patient support surface by the upper cushion layer.

17. The cushion of claim **16**, wherein the pressure redistribution assembly is located between the upper cushion layer and the lower cushion layer.

18. The cushion of claim **15**, wherein the pressure redistribution assembly is located along a top surface of the cushion.

19. The cushion of claim **15**, wherein the pressure redistribution assembly is located along a bottom surface of the cushion.

20. The cushion of claim **15**, further including a power conduit extending through the envelope providing power to the pressure redistribution assembly.

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