



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**05.08.2015 Bulletin 2015/32**

(51) Int Cl.:  
**A61G 7/057** (2006.01) **A61B 5/00** (2006.01)  
**A61G 7/05** (2006.01) **A61B 5/01** (2006.01)  
**A61B 5/103** (2006.01) **A47C 27/08** (2006.01)

(21) Application number: **15161193.6**

(22) Date of filing: **15.09.2010**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**

(72) Inventor: **Lachenbruch, Charles A.**  
**Lakeway, TX Texas 78734 (US)**

(30) Priority: **18.09.2009 US 243622 P**

(74) Representative: **Findlay, Alice Rosemary**  
**Reddie & Grose LLP**  
**16 Theobalds Road**  
**London WC1X 8PL (GB)**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:  
**10176760.6 / 2 298 264**

Remarks:

This application was filed on 26-03-2015 as a divisional application to the application mentioned under INID code 62.

(71) Applicant: **Hill-Rom Services, Inc.**  
**Batesville, IN 47006-9167 (US)**

(54) **Patient support surface index control**

(57) A control system of a patient support surface calculates a surface performance index as a function of pressure and shear. The control system also receives information from an electronic medical record (EMR) cor-

responding to a person's susceptibility of developing at least one of a pressure ulcer and a superficial lesion and adjusts at least one of a component and a characteristic of the person support surface based on the information.

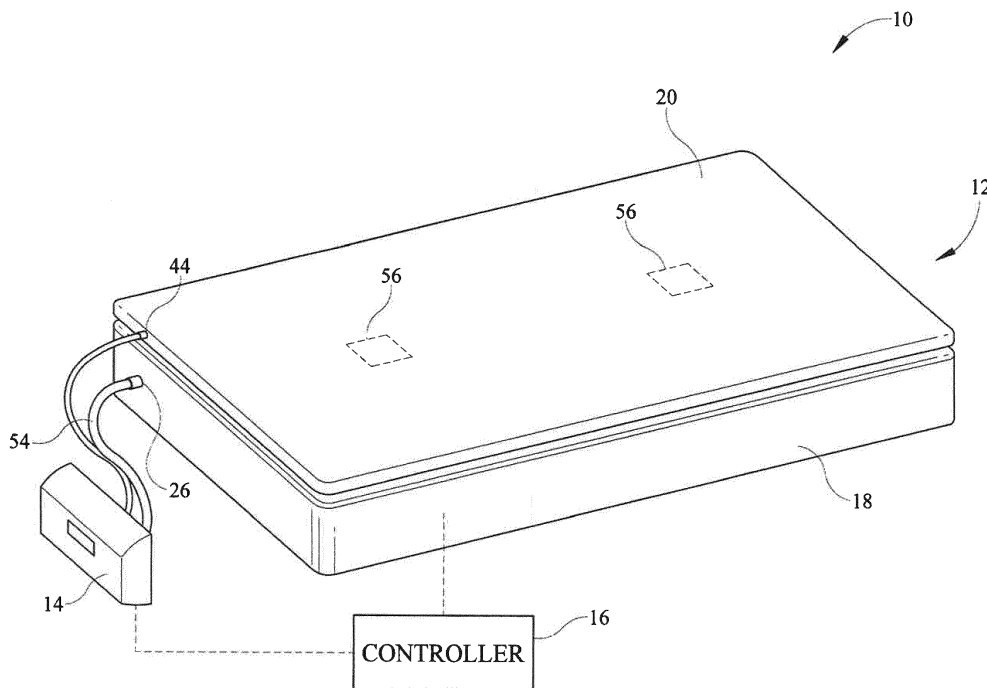


FIG. 1

**Description**

[0001] The present disclosure relates to person support surfaces such as mattresses. More particularly, the present disclosure relates to inflatable person support surfaces having controllers that regulate supply of a fluid as a function of various characteristics of the person support surfaces.

[0002] Persons lying on support surfaces, such as hospital bed mattresses, for extended periods of time are susceptible to the development of pressure ulcers (also known as decubitus ulcers or bedsores). Pressure ulcers oftentimes are lesions found adjacent to bony or cartilaginous areas. While many devices and methods have been developed to reduce the occurrence of pressure ulcers, there is still room for improvement. Thus there remains a need for further contributions in this area.

[0003] The present disclosure includes one or more of the following features, alone or in any combination.

[0004] A person support surface may include at least one inflatable bladder, a cover including a portion above the at least one inflatable bladder, and a control system. The control system may include a plurality of sensors that generate data signals indicative of a characteristic of the at least one inflatable bladder and a person's tissue contacting the cover and a processor operatively coupled to the plurality of sensors. The processor may be configured to execute operating logic to determine a surface performance index as a function of the data signals. The control system may have a fluid supply coupled to the at least one inflatable bladder. The processor may control the operation of the fluid supply as a function of the surface performance index.

[0005] The control system may be coupled to an electronic medical record (EMR) over a network and may receive information from the EMR for use by the processor in controlling the operation of the fluid supply. The information from the EMR may include a Braden score, pressure ulcer history, superficial lesion history, height, weight, and/or an identification of the person's medication. The control system may alert a caregiver if the fluid supply is unable to be operated to achieve the surface performance index.

[0006] The surface performance index may be a function of interface pressure, shear, and temperature. The control system may receive information regarding ambient conditions proximate the person support surface and the control system may modify the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the information regarding the ambient conditions. In some instances, the processor may use a look up table to determine the surface performance index. In other instances, the processor may use the following equation to determine the surface performance index:

$$\text{Surface\_Performan\textit{e}}\_Index = \frac{\left[ \frac{\left( \frac{SPL_1}{SPL_{\text{unloaded}}} \right)}{\left( \frac{DMD_1}{DMD_{\text{unloaded}}} \right)} \right]}{\left[ 1.00 - \frac{\left[ P_1^2 + S_1^2 \right]^{1/2}}{P_{\text{occlusion}}^2} \right]} \cdot \left( \frac{\left( \frac{\text{tissue\_temp. } ^\circ\text{C}}{W} \right) * THW + 37.78}{m^2} \right)$$

(1 + %\_reduction\_in\_tissue\_demand)

[0007] The control system may be configured to adjust at least one of an operating parameter and characteristic of a therapy delivered by the fluid supply via the at least one inflatable bladder. The therapy may comprise, for example, at least one of low air loss therapy, percussion vibration therapy, and continuous lateral rotation therapy.

[0008] The at least one inflatable air bladder may include a plurality of inflatable air bladder that are grouped into zones, each zone being inflated by the fluid supply so as to achieve different surface performance indexes. The control system may operate to adjust a first pressure in the at least one air bladder to a second pressure. The second pressure may be configured to lower the combined score  $(P^2 + S^2)^{1/2}$  in which P corresponds to a pressure measurement and S corresponds to a shear measurement.

[0009] At least one of a temperature, humidity, and flow rate of the fluid supplied by the fluid supply may be adjustable. In some embodiments, at least two or all three of a temperature, humidity, and flow rate of the fluid supplied by the fluid supply may be adjustable. The plurality of sensors may include a pressure sensor, a shear sensor and a temperature sensor. In some embodiments, the plurality of sensors may further include a humidity sensor. The at least one bladder

may include a topper that extends over substantially an entire length and width of the person support surface.

**[0010]** Some embodiments include a control system for a person support system that may be configured to receive a first set of input signals from an electronic medical record (EMR), generate a surface performance index as a function of interface pressure (P), shear (S), and temperature (T) based on the first set of inputs, receive a second set of input signals from the EMR, determine if the relative contributions of P, S, and/or T should be modified based on the second set of input signals while maintaining the performance index, and regulate a fluid supply as a function of P, S, and T.

**[0011]** In some embodiments a control system for a person support system may be configured to receive a first set of input signals from an EMR, establish thresholds for interface pressure (P), shear (S), and temperature (T) based on the first set of inputs, receive a second set of input signals from a plurality of sensors corresponding to at least one of the bladder pressure, interface pressure, shear, temperature, and/or relative humidity of the tissue and/or person contacting surface, compare the sensed values with the corresponding thresholds, and regulate a fluid supply as a function of difference between the sensed P, S, and T values and the corresponding thresholds.

**[0012]** According to some embodiments, a control system for a person support system may be configured to receive a set of input signals from a plurality of sensors corresponding to the relative humidity of the tissue and/or person contacting surface, look up the value of the relative humidity in a table to determine desired surface performance characteristics, and regulate a fluid supply as a function of surface performance characteristics.

**[0013]** The invention will now be further described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a person support system according to one illustrative embodiment;  
 FIG. 2 is a cross-sectional view of a mattress and a topper of the person support system of FIG. 1 taken laterally across a width of the mattress and topper;  
 FIG. 3 is a diagrammatic top view of the mattress of FIG. 2 inflatable air bladders forming three support zones according to this disclosure;  
 FIG. 4 is diagrammatic side view of the mattress and the topper of FIG. 2 showing a flow of air, moisture, and heat with respect to the mattress and the topper;  
 FIG. 5 is diagrammatic view of a control system of the person support system of FIG. 1 according to this disclosure;  
 FIG. 6 is a flow chart illustrating one optional procedure executed by the control system of FIG. 5 according to this disclosure;  
 FIG. 7 is a flow chart illustrating a second optional procedure executed by the control system of FIG. 5 according to this disclosure; and  
 FIG. 8 is a flow chart illustrating a third optional procedure executed by the control system of FIG. 5 according to this disclosure.

**[0014]** According to some embodiments of the present disclosure, a control system for a person support system is configured to receive a first set of input signals from an electronic medical record (EMR), generate a surface performance index as a function of interface pressure (P), shear (S), and temperature (T) based on the first set of inputs, receive a second set of input signals from the EMR, determine if the relative contributions of P, S, and/or T should be modified based on the second set of input signals while maintaining the performance index, and regulate a fluid supply as a function of P, S, and T.

**[0015]** Alternatively or additionally according to this disclosure, a control system for a person support system is configured to receive a first set of input signals from an EMR, establish thresholds for interface pressure (P), shear (S), and temperature (T) based on the first set of inputs, receive a second set of input signals from a plurality of sensors corresponding to at least one of the bladder pressure, interface pressure, shear, temperature, and/or relative humidity of the tissue and/or person contacting surface, compare the sensed values with the corresponding thresholds, and regulate a fluid supply as a function of difference between the sensed P, S, and T values and the corresponding thresholds.

**[0016]** Further alternatively or additionally according to this disclosure, a control system for a person support system is configured to receive a set of input signals from a plurality of sensors corresponding to the relative humidity of the tissue and/or person contacting surface, look up the value of the relative humidity in a table to determine desired surface performance characteristics, and regulate a fluid supply as a function of surface performance characteristics.

**[0017]** Pressure ulcers sometimes form in areas where a person's tissue is under stress. Several factors have been identified as contributing to tissue break down. Some of the more widely accepted factors include mechanical stresses within the tissue, such as, compression, stretching and distortion of tissue caused by pressure and shear forces. Other factors, such as friction, body heat and moisture have also been identified as contributing to tissue break down. Traditionally, pressure ulcers were thought to result from a single breakdown mechanism: interface pressure and shear force. However, recent studies suggest that wounds generally identified as pressure ulcers can be broken down into different types of wounds resulting from at least two breakdown mechanisms. The first type can be a superficial lesion, which some studies suggest may not be the result of pressure at all and may never progress to deeper tissue layers. These

superficial lesions are generally the result of moisture and/or friction, often in combination with other chemical or bacterial irritants. The second type of pressure ulcer is of a type which a growing body of evidence strongly suggests is the result of deep tissue injury (DTI), driven by tissue deformation and ischemia in the skin and underlying areas of muscle and fat. There is some evidence that suggests that, at very high levels of pressure and shear, damage from the deformation alone can be the primary mechanism of damage, independent of the ischemic process. At more moderate levels of stress, such as is sometimes imposed by a support surface, the primary cause of breakdown is generally believed to be ischemia.

**[0018]** Pressure, shear, and temperature have well-defined and quantifiable roles in the ischemic breakdown process, but there is currently no clear-cut, quantifiable connection between skin moisture and ischemia or friction and ischemia. However, this does suggest that the reduction in tissue oxygen levels caused by a surface, which drives ischemic breakdown, could be viewed as a single function of pressure, shear, and temperature. According to this disclosure, this function is derived analytically with the analytical relationship between interface pressure (P), shear (S), and reduction in tcpO<sub>2</sub> defined by the following equation:

$$reduction\_in\_tcpO_2 = \sqrt{(P^2 + S^2)}$$

**[0019]** If the pressure at which perfusion can fully occluded (P<sub>occlusion</sub>) is examined, then the proportional reduction in blood supply to a tissue at a pressure P1 and a shear S1 can be expressed as:

$$proportional\_reduction\_in\_O_2 = 1.00 - \left[ \frac{P_1^2 + S_1^2}{P_{occlusion}^2} \right]^{1/2}$$

**[0020]** In this expression, the denominator is representative of the total tissue mechanical stress at any combination of pressure P1 and shear S1 that cause full occlusion. The numerator represents the total tissue mechanical stress under any set of arbitrary loading conditions. The expression can also be expressed in terms of the supply SPL of blood to the tissue as follows:

$$\frac{SPL_1}{SPL_{unloaded}} = 1.00 - \left[ \frac{P_1^2 + S_1^2}{P_{occlusion}^2} \right]^{1/2}$$

**[0021]** Tissue demand for oxygen is reduced by approximately 6-13% per 1° C that the tissue is cooled. The effect of altering the tissue temperature between two arbitrary temperatures T<sub>o</sub> and T<sub>1</sub> can be expressed as follows:

$$\frac{Demand\_for\_O_2\_at\_T_1}{Demand\_for\_O_2\_at\_T_o} = \frac{DMD_{T_1}}{DMD_{T_o}} = (1 + \%\_reduction\_in\_tissue\_demand)^{(T_o - T_1)}$$

**[0022]** Tissue demand for oxygen can also be expressed as a function of the cooling power of surfaces in terms of total heat withdrawal (THW) rather than tissue temperature. According to this disclosure, the relationship between tissue temperature and total heat withdrawal can be expressed as follows:

$$Tissue\_Temp = \left( \frac{tissue\_temp.\_F}{\frac{W}{m^2}} \right) * THW + 100 = \left( \frac{tissue\_temp.\_C}{\frac{W}{m^2}} \right) * THW + 37.78$$

**[0023]** Given the previous equation, the effect of temperature on tissue demand for oxygen relative to demand in an uncovered, thermoneutral state can be expressed as follows:

5

$$\frac{DMD_{T_1}}{DMD_{T_0}} = (1 + \%\_reduction\_in\_tissue\_demand) \left( \left( \frac{tissue\_temp\_^{\circ}C}{W} \right) \cdot THW + 37.78 \right) \frac{1}{m^2}$$

10

[0024] Generally, when the tissue is unloaded, the supply of oxygen and demand for oxygen is approximately equal, i.e., there generally is no net accumulation or removal of oxygen in the tissue or subcutaneous tissue layers. According to this disclosure, to assess the performance of a person support surface, the unloaded supply and unloaded demand values are compared to the measured supply and measured demand values as shown in the following equation:

15

$$Surface\_Performan\ae\_Index = \frac{\left( \frac{SPL_1}{SPL_{unloaded}} \right)}{\left( \frac{DMD_1}{DMD_{unloaded}} \right)} =$$

20

$$\left[ 1.00 - \frac{P_1^2 + S_1^2}{P_{occlusion}^2} \right]^{1/2}$$

25

$$\frac{\left( \left( \frac{tissue\_temp\_^{\circ}C}{W} \right) \cdot THW + 37.78 \right) \frac{1}{m^2}}{(1 + \%\_reduction\_in\_tissue\_demand)}$$

30

[0025] The higher the ratio, the greater the likelihood that the surface helps prevent pressure ulcers and/or superficial lesions from developing.

35

[0026] According to some embodiments of this disclosure, the multiple performance indices are plotted in an N-dimensional visualization space and are analyzed using statistical methods to generate equations that provide a fit for the performance indices. In some embodiments, the performance indices are plotted in a 2-dimensional visualization space and/or analyzed using multiple variable regression techniques. In other embodiments, a table is generated containing the multiple surface performance indices with corresponding values of interface pressure, shear force, and temperature. The table is used as a look-up table. An example of a look-up table having surface performance index values calculated according to this disclosure is provided as follows:

40

Table 1: Support Surface Performance Table				
	Pressure (mm Hg)	Shear (mm Hg)	THW (W/sq. m)	Performance Index (SPL/DMD)
Surface A	32	0.6	250	0.97
Surface B	47	2.2	87	0.40
Surface C	51	2.2	70	0.33
Surface D	52.5	3.2	62	0.31
Surface E	51	3.2	10	0.28
Surface F	56.5	2.9	53	0.26
Surface G	57	3.6	27	0.23
Surface H	70	4	12	0.05

55

It is contemplated by this disclosure that one or both of the analytical model and the statistical model is used, as desired, in ranking and/or controlling one or more functions of person support systems.

[0027] A person support system 10 suitable for being controlled according to one or both of the analytical model and the statistical model is shown in Fig. 1. The person support system 10 includes a person support surface 12, a fluid supply 14, and a control system 16. In some instances, the person support system 10 is used in the hospital setting and

is supported on a person support apparatus (not shown), such as a hospital bed, stretcher, or other support structure. If desired, the person support system 10 can be supported on a floor (not shown), although typically, that is not intended to be the most common arrangement. The person support system 10 is configured to help reduce the likelihood of developing pressure ulcers and/or superficial lesions by maintaining at least one of the interface pressure, temperature, moisture, shear force, and/or friction within predetermined ranges.

**[0028]** The person support surface 12 is configured to support a person thereon. In some embodiments, the person support surface 12 includes a mattress 18 and a mattress topper 20 as shown in FIGs. 1 and 2. In some embodiments, the mattress topper 20 is integrated into the mattress 18. That is, the mattress 18 and topper 20 are coupled together to form a support surface unit in some embodiments. In other embodiments, the mattress 18 is provided without the mattress topper 20. The mattress 18 in the illustrative example has multiple zones, such as, a first zone Z1 or head zone Z1, a second zone Z2 or seat zone Z2, and a third zone Z3 or foot zone Z3 as shown in Fig. 3. In some embodiments, the zones Z1-Z3 are independently controlled by the fluid supply 14.

**[0029]** The mattress 18 includes an outer mattress cover 22 or mattress ticking 22 that envelopes an area to define a mattress chamber 24, and a mattress inlet 26 as shown in FIG. 2. The mattress ticking 22 has a support contacting surface 28 that contacts the person support apparatus (or floor), and a topper contacting surface 30 that interfaces with the mattress topper 20. In some embodiments, the topper contacting surface 30 serves as a person contacting surface 30 where the mattress topper 20 is integrated into the mattress 18, or the person support surface 12 does not include a mattress topper 20. The mattress ticking 22 is composed of a urethane and/or polytetrafluoroethylene (PTFE) coated nylons or other fabrics, for example. It is contemplated by this disclosure that the mattress ticking 22 can be made of other materials, such as those that are configured to prevent water from passing therethrough while allowing vapor to be transmitted therethrough.

**[0030]** The mattress chamber 24 contains a plurality of fluid bladders 32 and a mattress spacer 34 therein as shown in FIG. 2. In some embodiments, the mattress 18 contains only one mattress bladder 32 within the mattress chamber 24. In some embodiments, the mattress 18 is made of a polymeric material, such as, foam, foam blocks, foam layers of varying density, and/or include foam borders, which are used in combination with fluid bladders 32 in some embodiments, which fluid bladders themselves may or may not have internal foam. In some embodiments, the bladders 32 and/or topper 20 provide therapy and/or low air loss functionality through varying air pressure, blowing air, or exhausting air. In some embodiments, the fluid bladders 32 are gas bladders 32 that are alternately inflated and deflated and the mattress spacer 34 is made of foam and positioned between the fluid bladders 32 and the mattress ticking 22. The bladders 32 are arranged to form bladder arrays 36 that are positioned adjacent one another and/or on top of one another with the bladders 32 in the same or a different orientation. In some embodiments, the bladders 32 and/or bladder arrays 36 are in communication with one another such that the fluid pressure in the bladders 32 and/or bladder arrays 36 is maintained as pressure is exerted on the bladders 32 and/or bladder arrays 36, e.g., supporting a person thereon. In some embodiments, the bladders 32 or bladder arrays 36 are connected together with a connector 38 that couples the bladders to the mattress inlet 26.

**[0031]** The bladders 32 and/or bladder arrays 36 are configured, in some instances, to deliver therapy to a person supported on the person support surface 12. In some embodiments, the bladders 32 and/or bladder arrays 36 deliver therapy through sequential pressure increases/decreases and/or rapid changes in pressure of the bladders 32 and/or bladder arrays 36 as shown in FIG. 3. For example, one or more sections of the surface 18 may provide alternating pressure therapy, continuous lateral rotation therapy, boost assistance, percussion/vibration therapy, and/or turn assistance. In some embodiments, the bladders 32 and/or bladder arrays 36 exhaust gas into the mattress chamber 24.

**[0032]** The mattress topper 20 is coupled to the mattress 18 and interfaces with the person supported on the person support surface 12 in some embodiments as shown in FIG. 4. In some embodiments, the mattress topper 20 is a low air loss topper 20. Low air-loss broadly refers to a feature of a support surface that provides a flow of air to assist in managing the heat and humidity (microclimate) of the tissue contacting a surface. There are two types of mechanisms that low air-loss support devices typically use to remove accumulated moisture and heat: convective evaporation and diffusive evaporation. Convective evaporation evaporates accumulated moisture by blowing air on the tissue. Diffusive evaporation evaporates accumulated moisture through and under the surface of the support device to cool the tissue without blowing air directly on the tissue. An example of a diffusive device is shown in FIG. 4 in which a person is lying on the support surface 12 in the supine position with fluid F1 flowing through the support surface 12 to remove heat H1 and moisture M1 radiated by the person. In some low air-loss support devices contemplated by this disclosure, a combination of diffusive and convective evaporation is used.

**[0033]** The mattress topper 20 includes a topper cover 40 or ticking 40 that defines a topper chamber 42, a topper inlet 44, a topper vent 46, and a spacer 48 as shown in FIG. 3. The topper ticking 40 includes a mattress contacting surface 50 and a person contacting surface 52. The mattress contacting surface 50 interfaces with the topper contacting surface 30. The person contacting surface 52 interfaces with a person lying thereon. The mattress contacting surface 50 and the patient contacting surface 52 are generally shaped to cooperate with the topper contacting surface 30 and are secured to one another along their respective edges by ultrasonic welding, for example, in order to form a substantially

fluid-tight seal. Alternatively or additionally, the mattress contacting surface 50 and the patient contacting surface 52 are secured to one another by adhesive, plastic welding, or other securing means, and are secured along various portions of the mattress contacting surface 50 and the patient contacting surface 52.

5 **[0034]** In one illustrative embodiment, the ticking 50 is vapor permeable and impermeable to both liquids and air. It is within the scope of this disclosure for the ticking 50 to be both vapor permeable and air permeable. In some embodiments, the mattress ticking 22 and the ticking 50 are made of the same material and have the same physical characteristics.

10 **[0035]** The inlet 44 is positioned along a side of the topper 20 and allows for fluid to be communicated from the control system 14 into the chamber 42 in the illustrative example as shown in FIGs. 2 and 3. The inlet 44 includes an inlet coupler that couples the control system 14 to the topper 20 such that there is a substantially fluid-tight seal between the inlet 44 and the topper 20.

**[0036]** The vent 46 or outlet 46 is positioned along a side of the topper 20 opposite the inlet 44 in the illustrative embodiment as shown in FIG. 2. The vent 46 allows fluid entering the inlet 44 and passing through the chamber 42 to exit the topper 20.

15 **[0037]** The spacer 48 is positioned within the chamber 42 and separates the mattress contacting surface 50 from the patient contacting surface 52 as shown in FIG. 2. It is contemplated that, in some embodiments, the spacer 48 is made of material(s) having a high fluid porosity and having some resistance against flattening, while not being so stiff as to increase interface pressure too dramatically. In some embodiments, the spacer 32 includes at least one bladder (not shown). In some embodiments, the mattress spacer 34 and the spacer 48 are made of a similar material and/or have similar physical characteristics. The thickness of the spacer 48 is between about .1" and .75" in some embodiments. It should be appreciated that the thickness of the spacer 48 can be greater than .75" if desired.

20 **[0038]** The fluid supply 14 is configured to supply fluid to the bladders 32, bladder arrays 36, and/or the mattress topper 20 as shown in FIG. 1. In some embodiments, there are multiple fluid supplies 14, with a first fluid supply supplying fluid to the bladders 32 or bladder arrays 36 and a second fluid supply 32 supplying fluid to the mattress topper 20. In some embodiments, the fluid supplies 14 include a gas blower 14 that supplies air to the bladders 32, bladder arrays 25 36, and/or the mattress topper 20. It is within the scope of this disclosure for the fluid supply 14 to supply various other gasses and/or liquids rather than air. In some embodiments, the fluid supply 14 is integrated into the mattress 16. In other embodiments, the fluid supply 14 is coupled to a person support apparatus or supported on other supporting structures. The fluid supply 14 supplies the fluid through a connector 54 to the inlet 26 of the mattress 16 and/or the inlet 44 of the mattress cover 20 in the illustrative example. In some embodiments, the fluid supply 14 is removably coupled to the inlet 26 of the mattress 16 and/or the inlet 44 of the mattress cover 20 through a hose 54. Optionally, the fluid supply 14 includes a heating/cooling element (not shown) that can heat/cool the fluid being supplied.

30 **[0039]** The control system 16 for person support system 10 includes a plurality of sensors 56 and a controller 58 operatively coupled to the fluid supply 14 and the plurality of sensors 56 as shown in FIGs. 1 and 5. The control system 16 is configured to control various functions of the person support surface 12, such as, administering therapy to a person supported on the person support surface 12. In some embodiments, the control system 16 is configured to communicate information about the person support system 10 over a hospital network (not shown) and/or alert caregivers. At least a portion of the control system 16 is integrated into and/or coupled to the support surface 12 in some embodiments. For example, the fluid supply 14, the plurality of sensors 56, and the controller 58 are all incorporated within the person support surface 12 in some instances.

35 **[0040]** The sensors 56 are operatively coupled to the controller 58 and are configured to sense various parameters, including, but not limited to, a temperature of a tissue and/or the person contacting surface 52, a relative humidity of the interface between a tissue and the person contacting surface 52, an amount of shear between the person contacting surface 52 and the tissue, and a pressure of the fluid inside the bladders 32. In some embodiments, the sensors 56 and the controller 58 are coupled to a network 60 and the controller 58 receives data signals from the sensors 56 over the 40 network 60. In some embodiments, the sensors 56 include temperature sensors 62 integrated into the person contacting surface 52 and configured to sense the temperature of a tissue contacting the person contacting surface 52. Alternatively of additionally, the sensors 56 include moisture sensors 64 integrated into the person contacting surface and configured to sense the relative humidity of the interface between a tissue and the person contacting surface 52.

45 **[0041]** Further alternatively or additionally, the sensors 56 include shear sensors 66 integrated into the person contacting surface 52 and configured to sense the amount of shear between the person contacting surface 52 and the tissue. Still further alternatively or additionally, the sensors 56 include bladder pressure sensors 68 positioned within the bladders 32 or between adjacent bladders 32 and configured to sense the fluid pressure within the bladders 32. Optionally, one or more of the sensors 56 comprise interface pressure sensors 70 integrated into the person contacting surface 52 and configured to sense the interface pressure between the tissue and the person contacting surface 52 by measuring 50 the amount of force on the person contacting surface 52. In some embodiments, the sensors 56 include sensors configured to sense environmental conditions, such as, ambient temperature and humidity. In some embodiments, the sensors 56 are integrated into the ticking 40 by being coupled to the ticking via a suitable coupler such as adhesive or via lamination, for example. In other embodiments, the sensors 56 are situated adjacent the ticking 40.

**[0042]** The sensors 56 are configured to generate analog and/or digital signals. In some embodiments, the sensors 56 generate an analog data signal and are connected directly to the controller 58 as shown in FIG. 5. In other embodiments, the sensors 56 are configured to produce a digital data signal, e.g., a serial digital data signal, and can be connected to the network 60, e.g., a Serial Peripheral Interface (SPI) network, to communicate with the controller 58 if desired.

**[0043]** The controller 58 is configured to regulate the fluid supply 14 to control various characteristics of the person support surface 12 in response to data signals received from the sensors 56 and/or from a person's electronic medical record (EMR). In some embodiments, the EMR is copied and stored locally on the controller 58 or in a memory location coupled to the network 60. In some embodiments, the controller 58 is configured to regulate the fluid supply 14 in accordance with parameters identified in a look-up table using the data signals from the sensors 56. Alternatively or additionally, the controller 58 is configured to regulate the fluid supply 14 as a function of the data signals from the sensors 56. In some embodiments, the controller 58 is configured to regulate the fluid supply 14 with parameters identified in a look-up table using information from the EMR of a person supported on the person support surface 12. In still other contemplated embodiments, the controller 58 is configured to regulate the fluid supply 14 in accordance with both the data signals and the EMR information. Alternatively or additionally, the controller 58 is configured to regulate the fluid supply 14 in accordance with a user input.

**[0044]** The controller 58 can be located in a variety of places. In some embodiments, the controller 58 is incorporated into a graphical user interface (not shown) and is configured to receive user inputs, e.g., from a caregiver and/or person supported on the person support apparatus. It is contemplated by this disclosure that the graphical user interface is coupled to the person support apparatus or support structure or equipment management system. In other embodiments, the controller 58 is integrated into an external network (not shown), such as a hospital network. In some embodiments, the controller 58 is integrated into the fluid supply 14.

**[0045]** The controller 58 includes memory 72, shown in FIG. 5, and stores data signals received from the sensors 56 in the memory 72 in some embodiments. In other embodiments, the memory 72 is separate from the controller 58. Alternatively or additionally, the controller 58 receives one or more user input signals from a user input device (not shown) that allows the person (caregiver and/or person supported on the person support system 10) to influence the regulation of the fluid supply 14. In some embodiments, the user input signal(s) is only able to influence the regulation of the fluid supply 14 within the predetermined ranges. The controller 58 is configured to execute operating logic 76 that defines various control, management, and/or regulation functions. This operating logic 74 is in the form of software, firmware, and/or dedicated hardware, such as, a series of programmed instructions, code, electronic files, or commands using general purpose or special purpose programming languages or programs executed on one or more general purpose or special purpose computers, processors, other control circuitry, or networks; a hardwired state machine; and/or a different form as would occur to those skilled in the art.

**[0046]** In some embodiments, the controller 58 includes operating logic 74 in the form of procedure 76 for example, as shown in the flowchart of FIG. 6. Procedure 76 includes operations/conditionals as indicated at blocks 78, 80, 82, 84, and 86. Procedure 76 is used to regulate the fluid supply 14 as a function of the data signals from the interface pressure sensors 70, the shear force sensors 66, and the temperature sensors 62.

**[0047]** Procedure 76 begins with the operation of block 78 wherein the controller 58 receives data from the EMR which data is indicative of the person's susceptibility to developing pressure ulcers and/or superficial lesions. The EMR data includes, for example, a person's height, weight, pressure ulcer history, superficial lesion history, medications being administered, medical conditions, skin condition, and/or resistance to friction and shear tearing forces. For example, medications like Pamelor for depression or Pylocarpine for Glaucoma may cause a person to sweat at a lower skin temperature. In another example, the medication Prednisone, which is used to combat inflammation, sometimes can significantly reduce the skin's resistance to friction and shear tearing forces. In still another example, medical conditions, such as, diabetes can inhibit a person's ability to sweat and lead to a higher skin temperature.

**[0048]** In the operation of block 80, the controller 58 uses the EMR data to identify standard hospital specific protocols that are, in turn, used to establish threshold values for interface pressure, shear, and temperature for the particular person. In some embodiments, the thresholds are generic pre-programmed thresholds. Alternatively or additionally, the thresholds are input by a user through the user interface and/or a remote location. In some embodiments, threshold values are also established for friction and moisture.

**[0049]** In the operation of block 82, the sensors 56 sense at least one of the interface pressure between the surface and a tissue, the amount of shear between the surface and the tissue, and the temperature of the tissue. In some embodiments, the sensors 56 also sense the moisture between the tissue and the person contacting surface 52. Alternatively or additionally, one or more of the sensors 56 sense environmental conditions, such as, ambient temperature and humidity. The sensors 56 post the sensed information as a value or an event on the network 60 in some embodiments.

**[0050]** In the conditional of block 84, the controller 58 determines if it subscribes to the information on the network 60 and, if it does, it inputs the information into the operating logic 74. For example, the controller 58 will elect to receive the data signal corresponding to the interface pressure, amount of shear, and the temperature in some embodiments. In the operation of block 86, if the controller 58 determines in the conditional of block 84 that the controller 58 subscribes

to the information, then the controller 58 compares the sensed information to corresponding threshold values.

**[0051]** In the conditional of block 88, if one or more of the sensed values is greater than the associated threshold value, the controller 58 regulates the fluid supply 14 as a function of the difference between the sensed value and the threshold value in the operation of block 90. In some embodiments, the controller 58 looks up the difference between the threshold and the sensed value in a look-up table to determine the corresponding desirable support surface characteristics and/or support surface performance index. The controller 58 then proceeds to cause the fluid supply 14 to increase/decrease the pressure within the fluid bladders 32 as appropriate. It has been found that increasing the pressure in fluid bladders 32 helps reduce friction and therefore, helps reduce instances of superficial lesions. It has been found that decreasing the pressure in the fluid bladders 32 helps reduce the instances of pressure ulcers. In some embodiments, the controller 58 causes the fluid supply 14 to raise/lower the temperature of the fluid within the fluid bladders 32 and/or flowing through the mattress topper 20. It has been found that lowering the temperature of the fluid flowing through the mattress cover 22 and/or the fluid contained within the fluid bladders 32 helps reduce instances of pressure ulcers and/or superficial lesions. In some embodiments, the controller 58 operates the fluid supply 14 so as to raise or lower the support surface performance index from a previous support surface performance index to a desirable support surface performance index. In some contemplated embodiments, the controller 58 operates the fluid supply 14 to maintain the existing support surface performance index while varying at least one of the interface pressure, shear force, and tissue temperature. In still other embodiments, the controller 58 regulates the fluid supply 14 as a function of the EMR data and the sensor signals. Alternatively or additionally, the controller 58 receives a user input and regulates the fluid supply 14 as a function thereof. In some embodiments, the user input corresponds to a person's comfort level and is allowed to vary the surface performance index by  $\pm 5\%$ . In still other embodiments, the controller 58 regulates the fluid supply 14 and the temperature of the fluid from the fluid supply 14 as a function of one or more environmental conditions, such as, ambient temperature and humidity.

**[0052]** In some embodiments, the controller 58 includes operating logic 74 in the form of procedure 92, for example, as shown in the flowchart of FIG. 7. Procedure 92 includes the operations/conditionals of blocks 94, 96, 98, and 100. Procedure 92 is used to regulate the fluid supply 14 as a function of the coefficient of friction of the surface and data signals from the moisture sensors 56 in some embodiments. It is contemplated by this disclosure that the coefficient of friction for the surface is stored in the memory 72. Alternatively or additionally, the coefficient of friction for the surface is entered by a user through a user interface. In some embodiments, the coefficients of friction for multiple surfaces are input into a table and a user (or the controller) selects the coefficient corresponding to the support surface 12 being used.

**[0053]** Procedure 92 begins with the operation of block 94 in which the sensors 56 sense the amount of moisture present at the interface between a tissue and a surface. The sensors 56 post the sensed information as a value or an event on the network 60. In the conditional of block 96, the controller 58 determines if it subscribes to the information on the network 60, and if it does, it inputs the information into the operating logic 74.

**[0054]** In the operation of block 98, if the controller 58 subscribes to the information, then the controller uses the information to determine a desirable set of support surface characteristics. In some embodiments, therefore, the controller 58 receives the data signal corresponding to the amount of moisture and determines a desirable set of support surface characteristics. In some embodiments, the controller 58 looks up the moisture value in a table and the corresponding coefficient of friction to determine the corresponding desirable support surface characteristics and/or support surface performance index. In some embodiments, the controller 58 calculates desirable support surface characteristics and/or support surface performance index as a function of the coefficient of friction and the amount of moisture.

**[0055]** In the operation of block 100 the controller 58 regulates the fluid supply 14 as a function of the desirable support surface characteristics. In some embodiments, the controller 58 operates the fluid supply 14 to increase/decrease the pressure within the fluid bladders 32. Alternatively or additionally, the controller 58 operates the fluid supply 14 to raise/lower the temperature of the fluid within the fluid bladders 32 and/or flowing through the mattress topper 20. Further alternatively or additionally, the controller 58 causes the fluid supply 14 to raise/lower the support surface performance index from a previous support surface performance index to the desirable support surface performance index. In some embodiments, the controller 58 operates the fluid supply 14 to maintain the existing support surface performance index while varying at least one of the amount of moisture (which can be accomplished by varying the temperature of the fluid flowing through the mattress cover 22 and/or the temperature of the fluid in the fluid bladders 32) and the coefficient of friction which can be modified by adjusting the firmness of the bladders 32. In other contemplated embodiments, the controller 58 receives a user input and regulates the fluid supply 14 as a function thereof. In some embodiments, the user input corresponds to a person's comfort level and is allowed to vary the surface performance index by  $\pm 5\%$ . In some embodiments, the controller 58 regulates the fluid supply 14 as a function of environmental conditions, such as, ambient temperature and humidity.

**[0056]** In yet other embodiments, the controller 58 includes operating logic 74 in the form of procedure 102, for example, as shown in the flowchart of FIG. 8. Procedure 102 includes the operations/conditionals of blocks 104, 106, 108, 110, 112, and 114. Procedure 102 is used to regulate the fluid supply 14 as a function of data from the EMR of the person supported on the person support surface 12.

[0057] Procedure 102 begins with the operation of block 104 in which the controller 58 receives a first set of information from the EMR corresponding to the person's susceptibility to developing pressure ulcers and/or superficial lesions. The first set of EMR information can include information, such as, for example, a Braden risk score, a person's height, weight, pressure ulcer history, superficial lesion history, and other similar information.

[0058] In the operation of block 106 the controller 58 uses the first set of EMR information to calculate a surface performance index as a function of interface pressure, shear, and temperature. In some embodiments, the controller 58 looks up the first set of EMR information in a lookup table that identifies support surface characteristics and/or support surface performance indices. In some embodiments, at least some of the values in the table are based on the National Clearinghouse Guidelines. According to some embodiments contemplated by this disclosure, the surfaces are tested to determine the P, S, and T indices for each and then converted to a performance index, which may correspond to a single Braden risk score or range or risk scores, for example. In other embodiments, the controller 58 examines the Braden risk score to determine the level of risk the person is at and then identifies surfaces that have a performance index corresponding to the level of risk. In some embodiments, the controller 58 uses mathematical algorithms to calculate the support surface performance index as a function of interface pressure, shear, and temperature based on the first set of EMR information.

[0059] In the conditional of block 108, the controller 58 determines which person support surfaces 12 are appropriate for the person. In some embodiments, the controller 58 outputs the index to a display (not shown) and a caregiver selects the appropriately rated person support surface 12. Alternatively or additionally, the controller 58 outputs a list of person support surfaces 12 rated at or above the index to a display (not shown). In some embodiments, the controller 58 is programmed with a surface identifier that includes a performance index that the person support surface is rated for, and alerts the caregiver, audibly or visually, whether the surface is rated at least one of below the index and greater than or equal to the index. In some embodiments, the controller 58 controls a person support surface 12 to change its initial performance index so that the person support surface 12 is operating at the calculated performance index.

[0060] In the operation of block 110, the controller 58 receives a second set of information from the EMR corresponding to the person's medical information. The second set of EMR information includes medical information, such as, for example, a person's medical diagnosis information and/or history, current and/or previous medications, personal preferences, current superficial lesions, current pressure ulcers, and other similar information.

[0061] In the conditional of block 112, the controller 58 determines if and by how much the relative contributions of pressure, shear, and temperature should be adjusted based on the second set of EMR information while maintaining the performance index. In one example, medications like Pamelor for depression or Pylocarpine for Glaucoma can cause a person to sweat at a lower skin temperature, which suggests that the flow rate of the fluid from the fluid supply 14 should be increased and/or the temperature reduced. In another example, the medication Prednisone, which can be used to combat inflammation, can significantly reduce the skin's resistance to friction and tearing forces, which suggests that the pressure in the fluid bladders 32 should be increased. In still another example, medical conditions, such as, diabetes can inhibit a person's ability to sweat and lead to a higher skin temperature, which suggests that the flow rate of the fluid from the fluid supply 14 should be increased and/or the temperature should be reduced.

[0062] In the operation of blocks 114, the controller 58 further regulates the fluid supply 14 as a function of parameters other than the interface pressure, shear, and temperature values established in operation 110 to maintain the person support surface 12 at the performance index established in operation 106. In some embodiments, the controller 58 causes the fluid supply 14 to increase/decrease the pressure within the fluid bladders 32 based on these other parameters. In some embodiments, the controller 58 causes the fluid supply 14 to raise/lower the temperature of the fluid communicated to the fluid bladders 32 and/or through the mattress topper 20 based on these other parameters. Alternatively or additionally, the controller 58 causes the fluid supply 14 to adjust the bladder 32 pressures and/or the temperature of the fluid in the bladders 32 and/or flowing through the mattress topper 20 to raise/lower the support surface performance index from an initial support surface performance index to the calculated support surface performance index based on these other parameters. In some embodiments, the controller 58 causes the fluid supply 14 to maintain the existing support surface performance index while varying the performance of the fluid supply 14 as a function of at least one of the interface pressure, shear force, and tissue temperature. Alternatively or additionally, the controller 58 receives a user input and regulates the fluid supply 14 as a function thereof. In some embodiments, the user input corresponds to a person's comfort level and is allowed to vary the surface performance index by  $\pm 5\%$ . In some embodiments, the controller 58 regulates the fluid supply 14 as a function of environmental conditions, such as, ambient temperature and humidity.

[0063] Embodiments of the invention can be described with reference to the following numbered clauses, with preferred features laid out in the dependent clauses:

1. A person support surface comprising at least one inflatable bladder, a cover including a portion above the at least one inflatable bladder, and a control system including a plurality of sensors that generate data signals indicative of a characteristic of the at least one inflatable bladder and a person's tissue contacting the cover, a processor oper-

- actively coupled to the plurality of sensors, the processor being configured to execute operating logic to determine a surface performance index as a function of the data signals, and a fluid supply coupled to the at least one inflatable bladder, the processor controlling the operation of the fluid supply as a function of the surface performance index.
2. The person support surface of any of the numbered clauses herein, wherein the control system is coupled to an electronic medical record (EMR) over a network and receives information from the EMR for use by the processor in controlling the operation of the fluid supply.
  3. The person support surface of any of the numbered clauses herein, wherein the information includes a Braden score.
  4. The person support surface of any of the numbered clauses herein, wherein the information includes at least one of pressure ulcer history and superficial lesion history.
  5. The person support surface of any of the numbered clauses herein, wherein the information includes at least one of height and weight.
  6. The person support surface of any of the numbered clauses herein, wherein the information includes an identification of the person's medication.
  7. The person support surface of any of the numbered clauses herein, wherein the surface performance index is a function of interface pressure, shear, and temperature.
  8. The person support surface of any of the numbered clauses herein, wherein the control system receives information regarding ambient conditions proximate the person support surface and the control system modifies the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the information regarding the ambient conditions.
  9. The person support surface of any of the numbered clauses herein, wherein the processor uses a look up table to determine the surface performance index.
  10. The person support surface of any of the numbered clauses herein, wherein the processor uses the following equation to determine the surface performance index:

$$\begin{aligned}
 \text{Surface\_Performance\_Index} = & \frac{\left( \frac{\text{SPL}_1}{\text{SPL}_{\text{unloaded}}} \right)}{\left( \frac{\text{DMD}_1}{\text{DMD}_{\text{unloaded}}} \right)} = \\
 & \frac{\left[ 1.00 - \left[ \frac{\text{P}_1^2 + \text{S}_1^2}{\text{P}_{\text{occlusion}}^2} \right]^{1/2} \right]}{\left( \left( \frac{\text{tissue\_temp. } ^\circ\text{C}}{\text{W}} \right) \cdot \text{THW} + 37.78 \right)} \\
 & \left( 1 + \% \text{reduction in tissue demand} \right)
 \end{aligned}$$

11. The person support surface of any of the numbered clauses herein, wherein the control system is configured to adjust at least one of an operating parameter and characteristic of a therapy delivered by the fluid supply via the at least one inflatable bladder.
12. The person support surface of any of the numbered clauses herein, wherein the therapy comprises at least one of low air loss therapy, percussion vibration therapy, and continuous lateral rotation therapy.
13. The person support surface of any of the numbered clauses herein, wherein the control system alerts a caregiver if the fluid supply is unable to be operated to achieve the surface performance index.
14. The person support surface of any of the numbered clauses herein, wherein the at least one inflatable air bladder comprises a plurality of inflatable air bladder that are grouped into zones, each zone being inflated by the fluid supply so as to achieve different surface performance indexes.
15. The person support surface of any of the numbered clauses herein, wherein the control system operates to adjust a first pressure in the at least one air bladder to a second pressure, the second pressure being configured to lower the combined score  $(P^2 + S^2)^{1/2}$  in which P corresponds to a pressure measurement and S corresponds to a shear measurement.
16. The person support surface of any of the numbered clauses herein, wherein at least one of a temperature, humidity, and flow rate of the fluid supplied by the fluid supply is adjustable.
17. The person support surface of any of the numbered clauses herein, wherein at least two of a temperature,

humidity, and flow rate of the fluid supplied by the fluid supply is adjustable.

18. The person support surface of any of the numbered clauses herein, wherein the plurality of sensors comprise a pressure sensor, a shear sensor and a temperature sensor.

19. The person support surface of any of the numbered clauses herein, wherein the plurality of sensors further  
5 comprise a humidity sensor.

20. The person support surface of any of the numbered clauses herein, wherein the at least one bladder comprises a topper that extends over substantially an entire length and width of the person support surface.

21. A method of selecting a support surface, comprising: receiving a first input indicative of the temperature of a  
10 tissue; receiving a second input indicative of the shear force on a tissue; receiving a third input indicative of the interface pressure of a tissue; and calculating an index as a function of the first input, the second input, and the third input, the index being indicative of the performance of a person support surface with respect to the breakdown of the tissue over time, wherein the index is configured to at least one of control and select a person support surface.

22. A method of rating the performance of a support surface, comprising: receiving a first input indicative of the  
15 temperature of a tissue contacting the support surface; receiving a second input indicative of the shear force on the tissue contacting the support surface; receiving a third input indicative of the interface pressure of the tissue contacting the support surface; and calculating an index as a function of the first input, the second input, and the third input, the index being indicative of the performance of the support surface with respect to the breakdown of the tissue over time.

23. A control system for a person support surface, comprising: a plurality of sensors coupled to the person support  
20 surface and configured to generate at least one data signal; a processor operatively coupled to the plurality of sensors; and at least one storage device operatively coupled to the processor, wherein the at least one processor is operable to execute program instructions in order to: receive the at least one data signal from the plurality of sensors, calculate an index as a function of the at least one data signal, and control a fluid supply as a function of the index.

24. A person support surface, comprising: a fluid bladder array; a cover enveloping the fluid bladder array; a control  
25 system including: at least one sensor configured to generate data signals indicative of a characteristic of at least one of the fluid bladder array, the cover, and a tissue contacting the cover; and a processor operatively coupled to the at least one sensor, the processor being configured to execute operating logic to calculate an index as a function of the data signals; and a fluid supply coupled with the fluid bladder array, the processor controlling the operation of the fluid supply as a function of the index.

25. A method, comprising: receiving information from an electronic medical record corresponding to a person's  
30 susceptibility to developing at least one of a pressure ulcer and a superficial lesion; and adjusting at least one of a component and a characteristic of at least one of a person support surface and a person support apparatus based on the information.

26. A method, comprising: inflating a fluid bladder to a first pressure, the fluid contained within the fluid bladder  
35 being at a first temperature; receiving information from an electronic medical record corresponding to a person's susceptibility to developing at least one of a pressure ulcer and a superficial lesion; and adjusting at least one of the pressure of the fluid within the fluid bladder to a second pressure and the temperature of the fluid within the fluid bladder to a second temperature as a function of the information.

27. A method, comprising: receiving information from an electronic medical record corresponding to a person's  
40 susceptibility to developing at least one of a pressure ulcer and a superficial lesion; calculating a surface performance index as a function of the information; and selecting at least one of a person support surface configured to perform at about the surface performance index and a person support surface configurable to perform at about the surface performance index.

28. A method, comprising: receiving information from an electronic medical record corresponding to a person's  
45 susceptibility to developing at least one of a pressure ulcer and a superficial lesion; and regulating at least one of a flow rate and a temperature of a fluid supplied by a fluid to a person support surface.

29. A method, comprising: receiving information from an electronic medical record; determining a susceptibility of  
a person to developing at least one of pressure ulcers and superficial lesions based on the information; and selecting a person support surface based on the susceptibility.

30. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein a controller  
50 receives the information over a network.

31. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the information  
includes a Braden score.

32. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the information  
55 includes at least one of pressure ulcer history and superficial lesion history.

33. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the information  
includes physiological data.

34. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the physiological

data includes at least one of height and weight.

35. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the index is displayed on a display.

36. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein a list of person support surfaces at least one of performing at about the surface performance index and configurable to perform at about the surface performance index being displayed on a display.

37. A person support surface or person support apparatus including an identifier, the controller comparing the identifier with at least one of the support surface index and the list of person support surfaces to determine if the person support surface at least one of performs at about the surface performance index and is configurable to perform at about the surface performance index.

38. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the surface performance index is a function of interface pressure, shear, and temperature.

39. The method, apparatus, surface, and/or system of any of the numbered clauses herein further comprising the steps of receiving a second set of information from the electronic medical records modifying the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the second set of information regulating a fluid supply as a function of the interface pressure, shear, and temperature while maintaining the person support surface index.

40. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the second set of information includes the person's medical diagnosis history.

41. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the second set of information includes the person's medication history.

42. The method, apparatus, surface, and/or system of any of the numbered clauses herein further comprising the steps of receiving a second set of information from the electronic medical records sensing ambient conditions proximate the person support surface modifying the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the second set of information and the ambient conditions regulating a fluid supply as a function of the interface pressure, shear, and temperature while maintaining the performance of the person support surface at about the person support surface index.

43. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller utilizes a look up table to determine the index.

44. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller utilizes the following equation to determine the index:

$$\begin{aligned}
 \text{Surface\_Performan\textit{e}}\_Index = & \frac{\left( \frac{SPL_1}{SPL_{\text{unloaded}}} \right)}{\left( \frac{DMD_1}{DMD_{\text{unloaded}}} \right)} = \\
 & \frac{\left[ 1.00 - \left[ \frac{P_1^2 + S_1^2}{P_{\text{occlusion}}^2} \right]^{1/2} \right]}{\left( \left( \frac{\text{tissue\_temp. } ^\circ\text{C}}{W} \right)^{THW+37.78} \right)^{m^2}} \\
 & (1 + \% \_reduction\_in\_tissue\_demand)
 \end{aligned}$$

45. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller is configured to modify a characteristic of the person support surface to reduce the risk of developing pressure ulcers.

46. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller is configured to modify a characteristic of the person support surface to reduce the risk of developing superficial lesions.

47. The method, apparatus, surface, and/or system of any of the numbered clauses herein further comprising the steps of receiving a second set of information from the electronic medical records sensing ambient conditions proximate the person support surface modifying the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the second set of information and the ambient conditions regulating a fluid supply as a function of the interface pressure, shear, and temperature while maintaining the performance of

the person support surface at about the person support surface index.

48. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller is configured to adjust a characteristic of the person support surface based on the information.

5 49. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller is configured to adjust at least one of an operating parameter and characteristic of a therapy delivered by the person support surface.

50. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the therapy is low air loss therapy.

10 51. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the therapy is percussion vibration therapy.

52. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the therapy is continuous lateral rotation.

53. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the support surface includes an identifier configured to identify the support surface to the controller.

15 54. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller can alert a caregiver if the support surface is not one of configured and configurable to operate at the surface performance index.

55. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the support surface includes a plurality of zones, the zones being configured to operate independent of one another.

20 56. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the zones are configured to operate at different surface performance indexes.

57. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the information includes at least one of medications is currently taking and medical diagnoses.

25 58. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the susceptibility is in the form of an index.

59. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the steps are performed by a computer.

60. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the step are performed by a caregiver.

30 61. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein a table for a given level of internal bladder pressure in each zone contains a corresponding interface pressure in each zone.

62. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein a table for a given level of at least one of an internal bladder pressure, a person's weight, and a person's height in each zone contains at least one of a corresponding interface pressure and shear for each zone.

35 63. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein a first pressure in an internal bladder is adjusted to a second pressure, the second pressure being configured to lower the combined score  $(P^2 + S^2)^{1/2}$ .

64. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the fluid supply is a gas supply.

40 65. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein at least one of a temperature, humidity, and flow rate of the fluid supplied by the fluid supply.

66. The method, apparatus, surface, and/or system of any of the numbered clauses herein, wherein the controller is configured to receive information corresponding to the weight of a person, bladder pressure, interface pressure, shear, and temperature in each zone.

45 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 restrictive in character, it being understood that only the selected embodiments have been shown and described.

50 **Claims**

1. A person support surface comprising  
 at least one inflatable bladder,  
 a cover including a portion above the at least one inflatable bladder, and  
 55 a control system including a plurality of sensors that generate data signals indicative of a characteristic of the at least one inflatable bladder and a person's tissue contacting the cover, a processor operatively coupled to the plurality of sensors, the processor being configured to execute operating logic to determine a surface performance index as a function of the data signals, and a fluid supply coupled to the at least one inflatable bladder, the processor

controlling the operation of the fluid supply as a function of the surface performance index, wherein the surface performance index is a function of interface pressure, shear, and temperature, and wherein the control system receives information regarding ambient conditions proximate the person support surface and the control system modifies the contributions of interface pressure, shear, and temperature to the surface performance index as a function of the information regarding the ambient conditions.

2. The person support surface of claim 1, wherein the control system is coupled to an electronic medical record (EMR) over a network and receives information from the EMR for use by the processor in controlling the operation of the fluid supply.
3. The person support surface of claim 2, wherein the information includes at least one of a Braden score, pressure ulcer history, superficial lesion history, height, weight and an identification of the person's medication.
4. The person support surface of any preceding claim, wherein the processor uses a look up table to determine the surface performance index.
5. The person support surface of any one of claims 1 to 3, wherein the processor uses the following equation to determine the surface performance index:

$$\text{Surface\_Performan\ae\_Index} = \frac{\left[ \frac{\left( \frac{\text{SPL}_1}{\text{SPL}_{\text{unloaded}}} \right)}{\left( \frac{\text{DMD}_1}{\text{DMD}_{\text{unloaded}}} \right)} \right]}{\left[ 1.00 - \left[ \frac{\text{P}_1^2 + \text{S}_1^2}{\text{P}_{\text{occlusion}}^2} \right]^{1/2} \right]} \cdot \left( \left( \frac{\text{tissue\_temp. } ^\circ\text{C}}{\frac{\text{W}}{\text{m}^2}} \right)^{\text{THW}+37.78} \right)$$

(1 + %\_reduction\_in\_tissue\_demand)

6. The person support surface of any preceding claim, wherein the control system is configured to adjust at least one of an operating parameter and characteristic of a therapy delivered by the fluid supply via the at least one inflatable bladder.
7. The person support surface of claim 6, wherein the therapy comprises at least one of low air loss therapy, percussion vibration therapy, and continuous lateral rotation therapy.
8. The person support surface of any preceding claim, wherein the control system alerts a caregiver if the fluid supply is unable to be operated to achieve the surface performance index.
9. The person support surface of any preceding claim, wherein the at least one inflatable air bladder comprises a plurality of inflatable air bladders that are grouped into zones, each zone being inflated by the fluid supply so as to achieve different surface performance indexes.
10. The person support surface of any preceding claim, wherein the control system operates to adjust a first pressure in the at least one air bladder to a second pressure, the second pressure being configured to lower the combined score  $(\text{P}^2 + \text{S}^2)^{1/2}$  in which P corresponds to a pressure measurement and S corresponds to a shear measurement.
11. The person support surface of any preceding claim, wherein at least two of a temperature, humidity, and flow rate of the fluid supplied by the fluid supply is adjustable.
12. The person support surface of any preceding claim, wherein the plurality of sensors comprise a pressure sensor,

a shear sensor and a temperature sensor.

13. The person support surface of claim 12, wherein the plurality of sensors further comprise a humidity sensor.

5

10

15

20

25

30

35

40

45

50

55

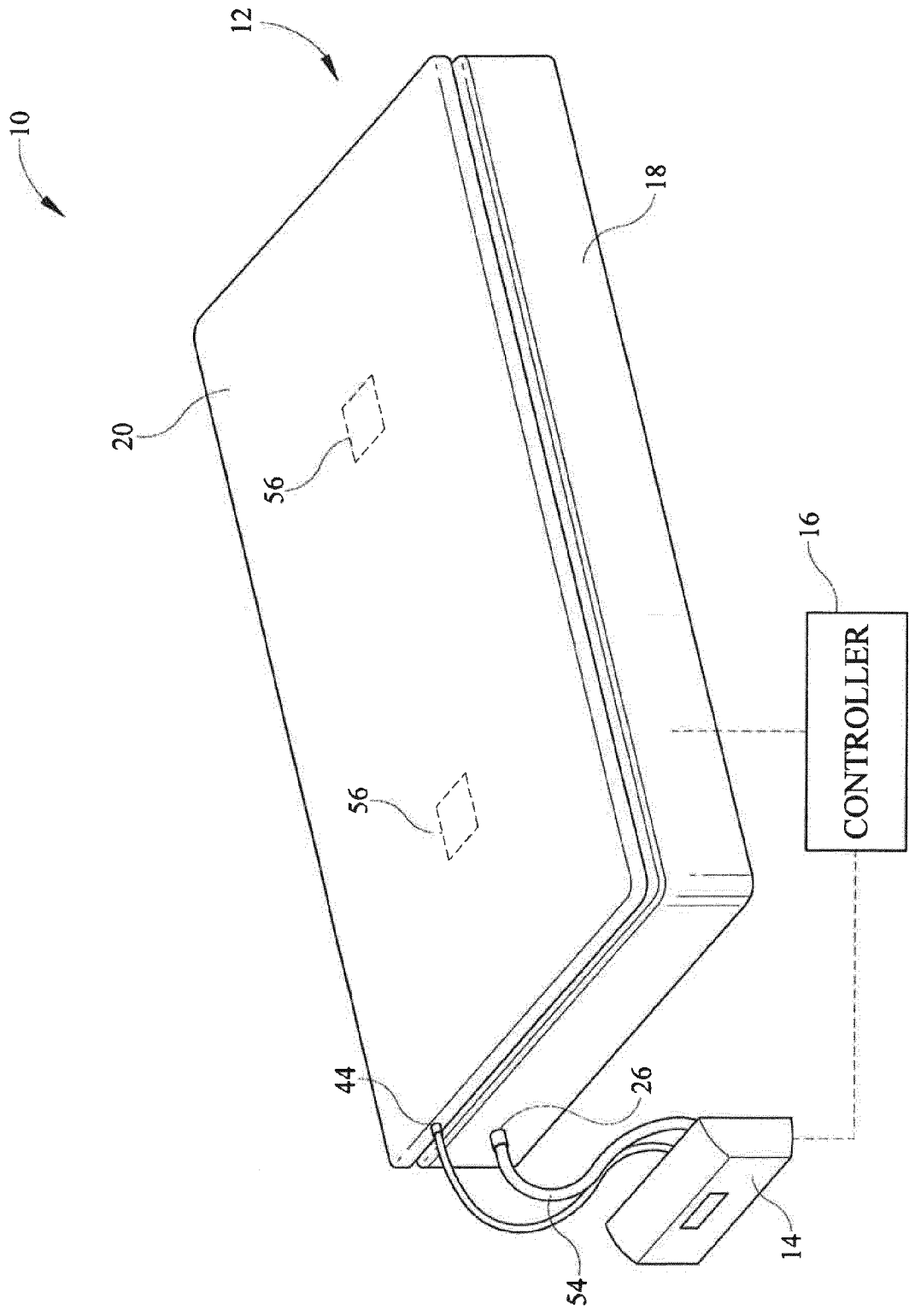


FIG. 1

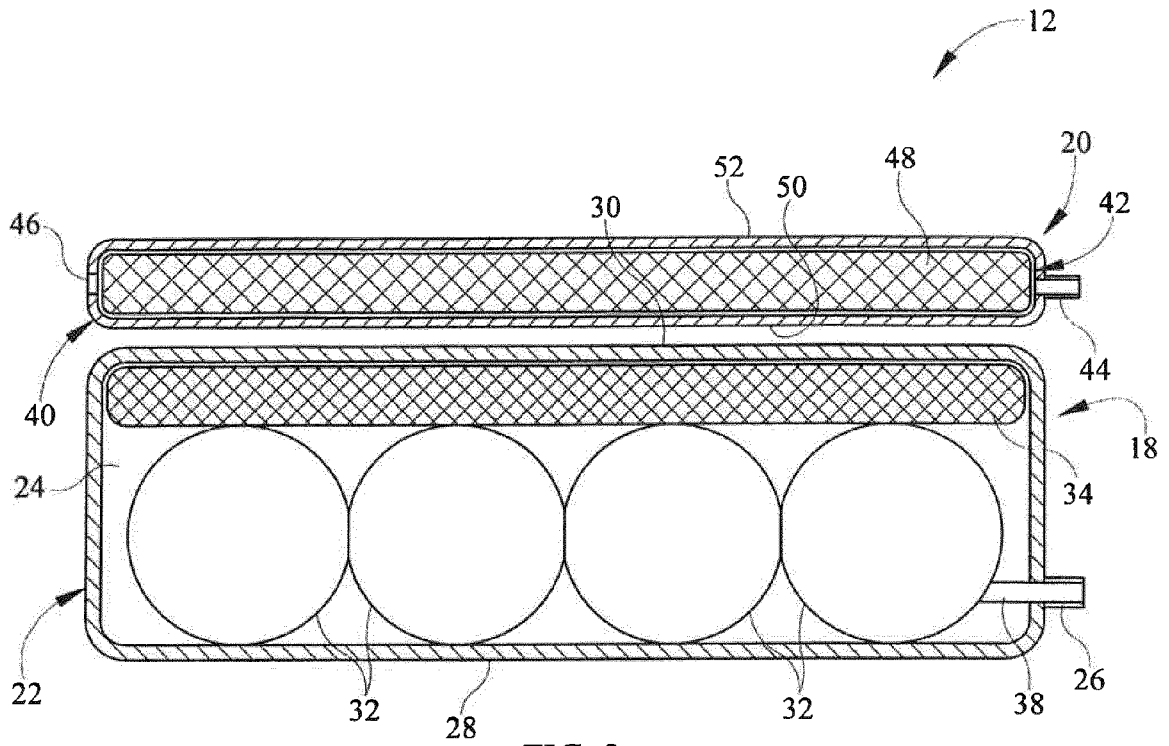


FIG. 2

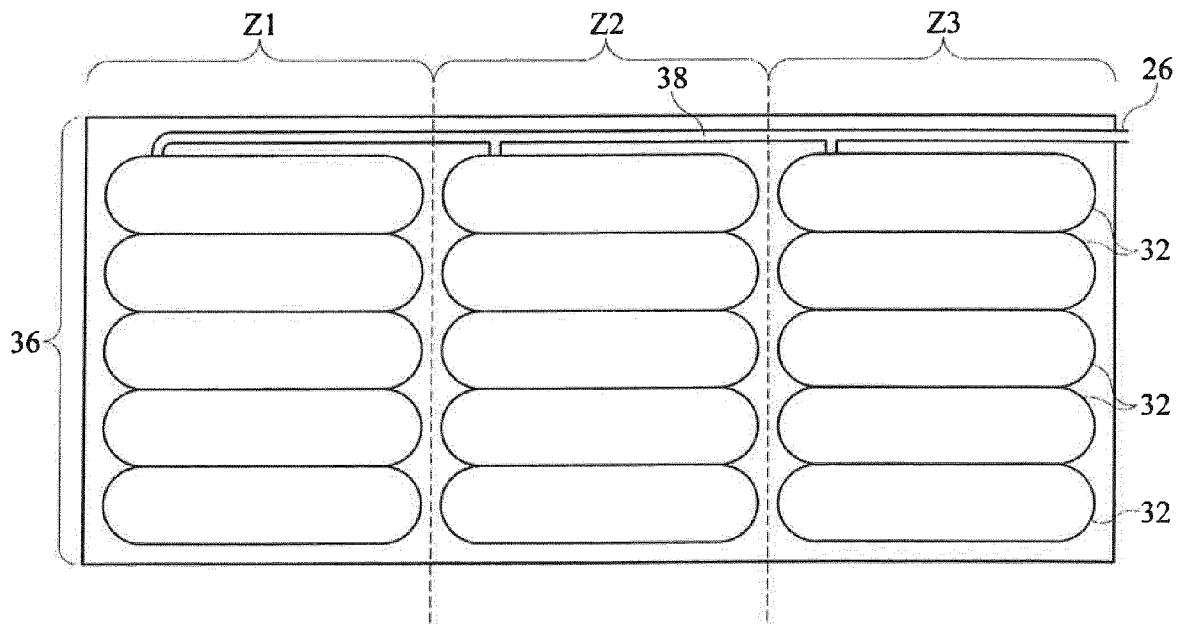


FIG. 3

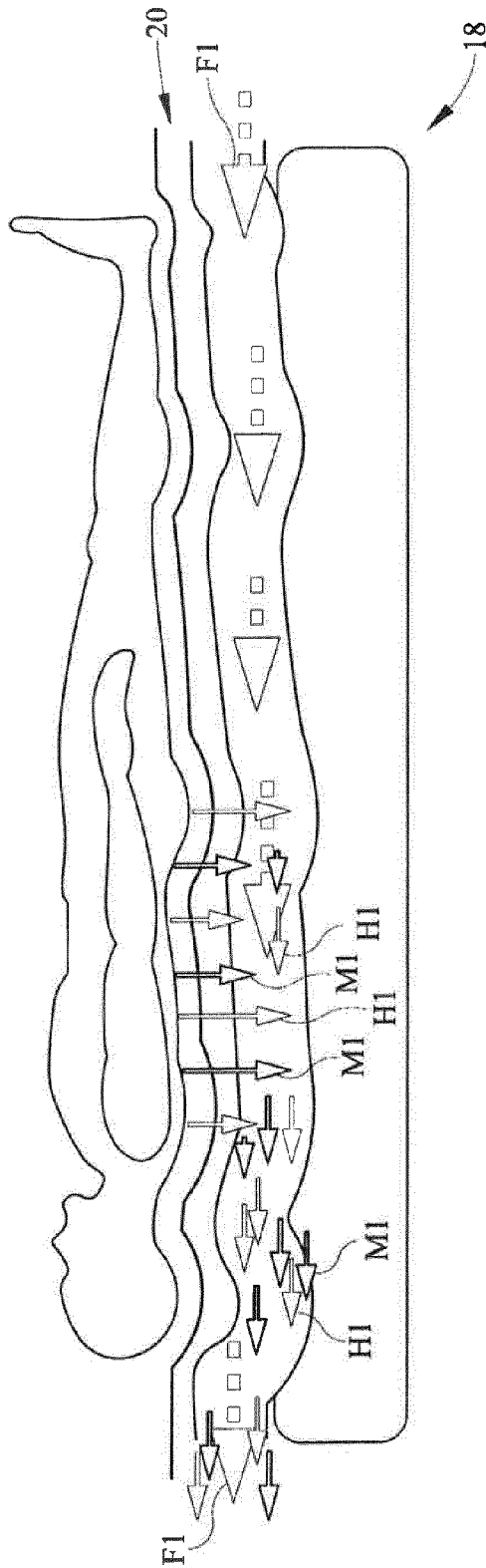


FIG. 4

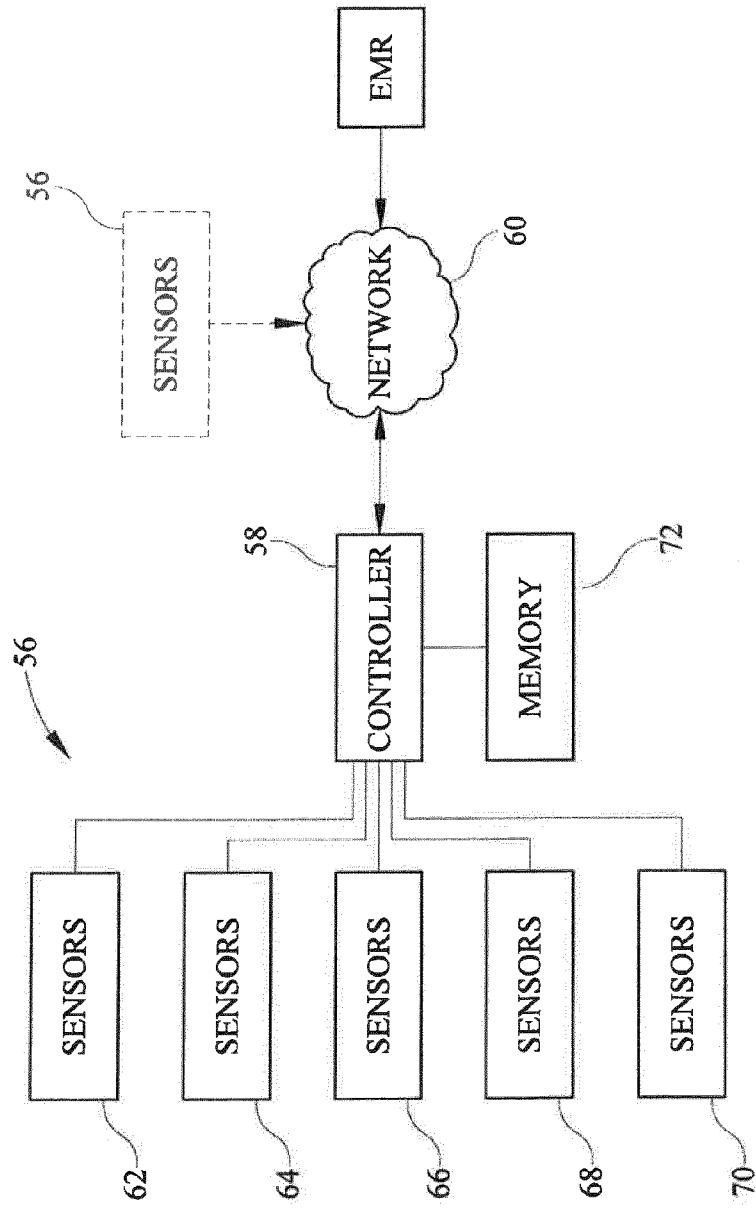


FIG. 5

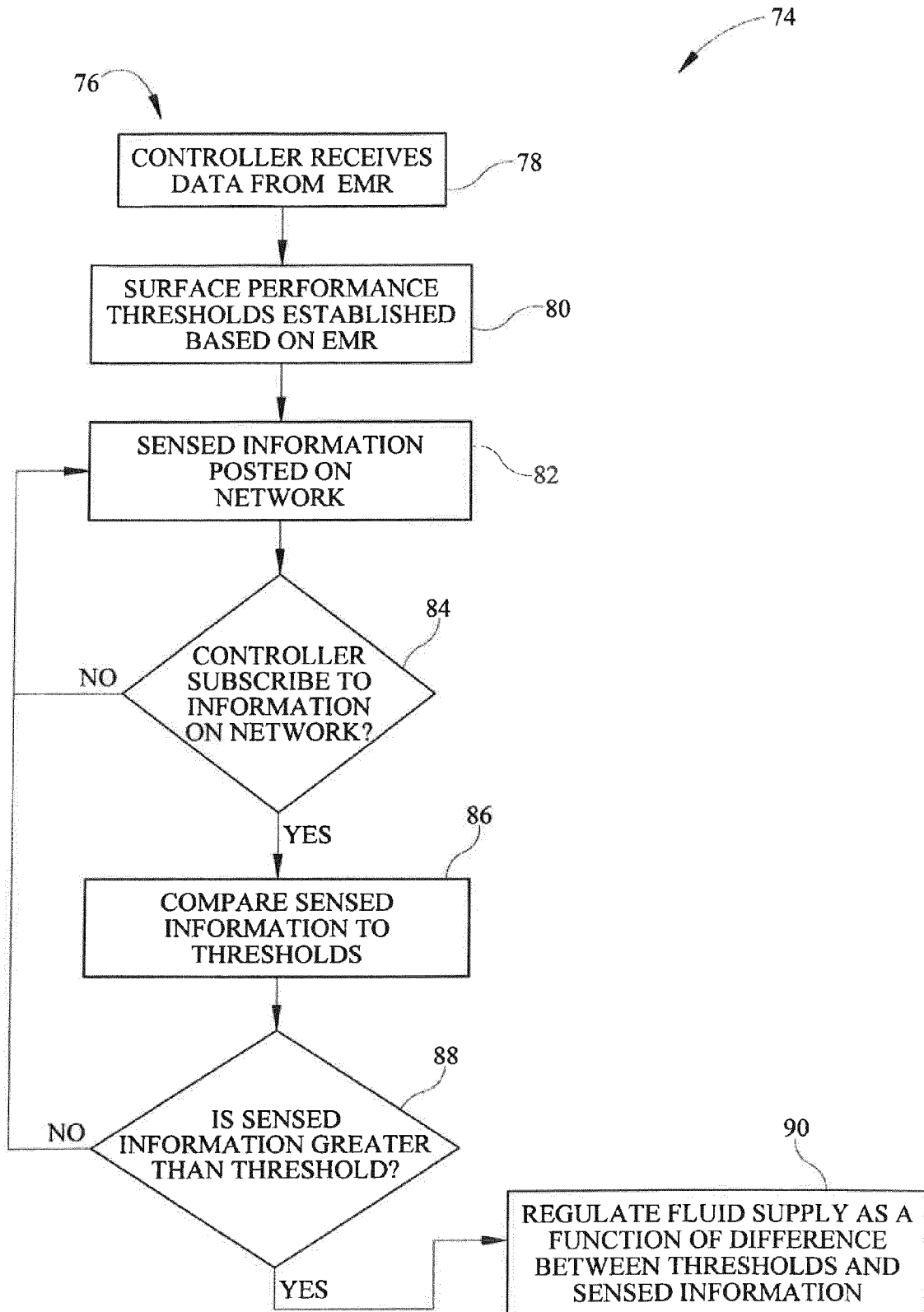


FIG. 6

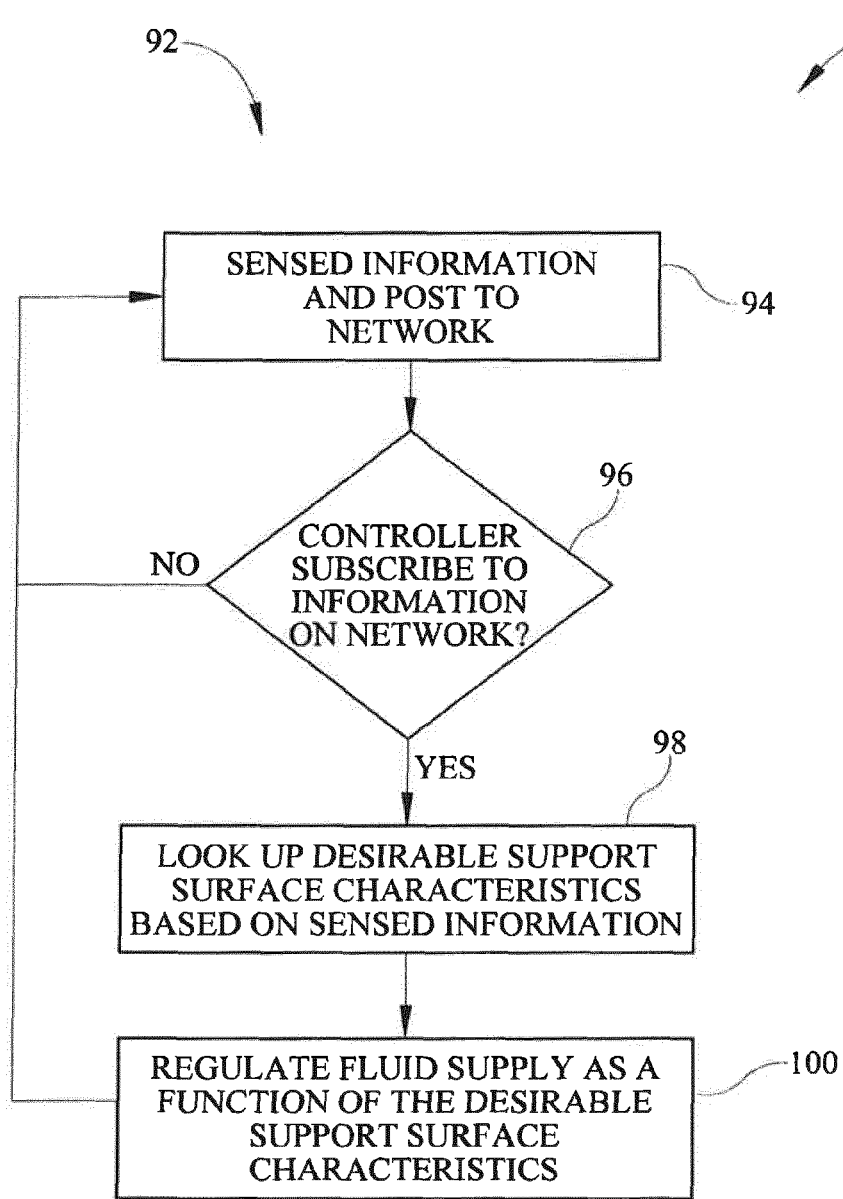


FIG. 7

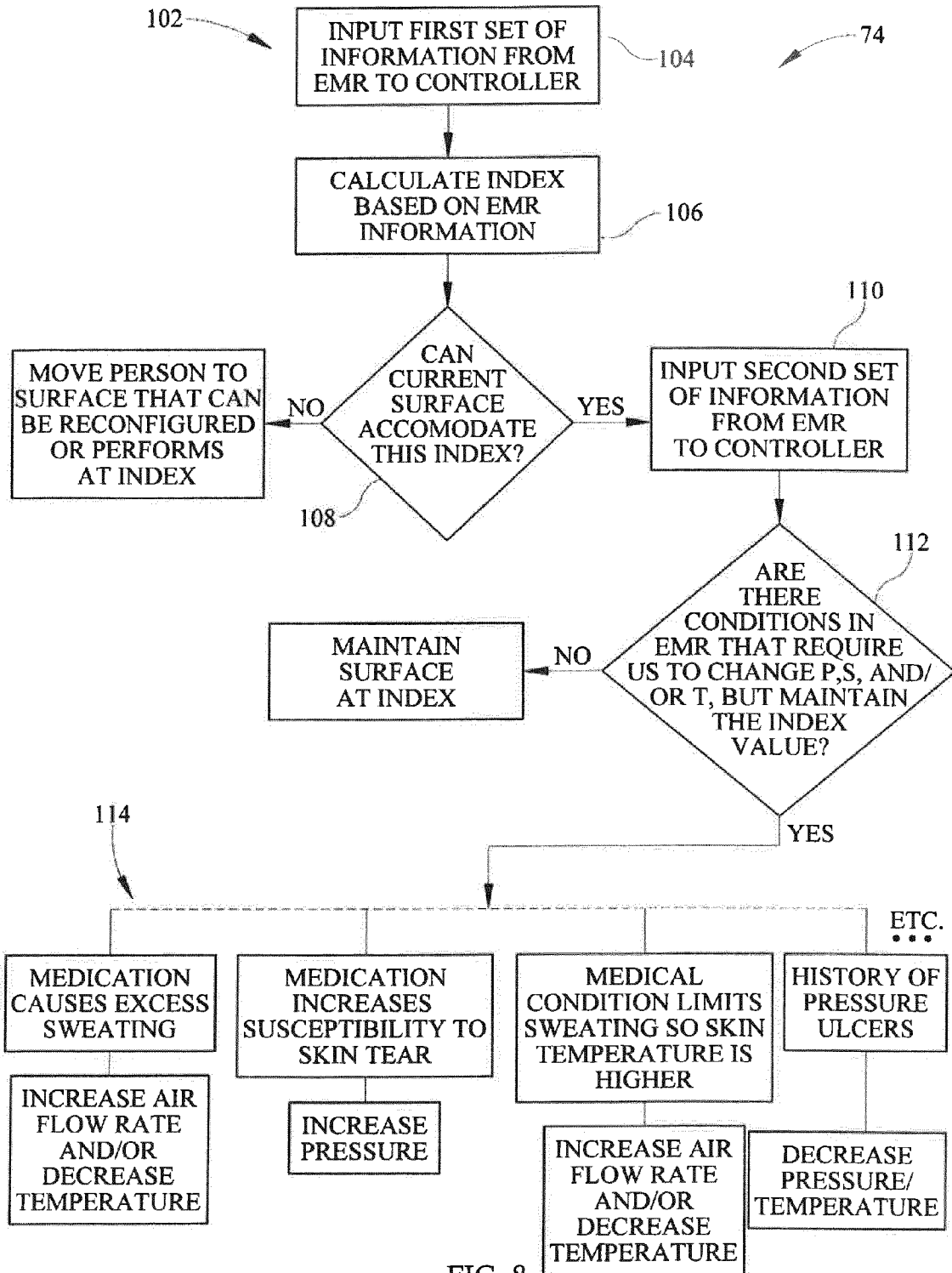


FIG. 8



EUROPEAN SEARCH REPORT

Application Number  
EP 15 16 1193

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 00/24353 A1 (HILL ROM CO INC [US]; PRICE JAMES H [US]; TAYLOR GEOFFREY LOCKE [CA]); 4 May 2000 (2000-05-04) * page 2, lines 9-12,29-32; figures 1-3,6-9 * * page 3, line 32 - page 4, line 1 * * page 7, lines 7-9 * * page 10, lines 22-30 * * page 17, lines 10-12 * * page 18, lines 12-15 *	1-13	INV. A61G7/057 A61B5/00 A61G7/05 A61B5/01 A61B5/103  ADD. A47C27/08
A	WO 2007/008831 A2 (HILL ROM CO INC; BOBEY JOHN A [US]; DOUGLAS STEPHEN L [US]; MEYER ERIC) 18 January 2007 (2007-01-18) * page 3, lines 7-8; figures 2-7,10,11,19,20,34 * * page 5, lines 31-33 * * page 6, lines 13-14,17-20 * * page 7, lines 17-19 * * page 9, lines 12-18 * * page 10, lines 6-7 * * page 11, lines 10-30 * * page 12, lines 13-20 * * page 13, lines 3-5,14-18,27-34 * * page 15, lines 18-23 * * page 17, lines 2-4,16-19 * * page 18, lines 7-10 * * page 28, lines 33-34 * * page 34, lines 4-5 *	1-13	TECHNICAL FIELDS SEARCHED (IPC)  A61G
A	US 5 970 789 A (MEYER ERIC R [US] ET AL) 26 October 1999 (1999-10-26) * column 1, lines 49-55 * * column 3, lines 27-36 *	1	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 June 2015	Examiner Gkama, Alexandra
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons  & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 15 16 1193

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-06-2015

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0024353 A1	04-05-2000	AU 1328400 A	15-05-2000
		BR 9914920 A	10-07-2001
		CA 2346207 A1	04-05-2000
		EP 1123074 A1	16-08-2001
		JP 2002528175 A	03-09-2002
		WO 0024353 A1	04-05-2000
WO 2007008831 A2	18-01-2007	AU 2006268288 A1	18-01-2007
		EP 1906794 A2	09-04-2008
		JP 5231222 B2	10-07-2013
		JP 5646562 B2	24-12-2014
		JP 2009500132 A	08-01-2009
		JP 2013013738 A	24-01-2013
		US 2009237264 A1	24-09-2009
		US 2012105233 A1	03-05-2012
		US 2013276237 A1	24-10-2013
WO 2007008831 A2	18-01-2007		
US 5970789 A	26-10-1999	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	患者支持面指数控制		
公开(公告)号	<a href="#">EP2901994A1</a>	公开(公告)日	2015-08-05
申请号	EP2015161193	申请日	2010-09-15
[标]申请(专利权)人(译)	希尔 - 罗姆服务股份有限公司		
申请(专利权)人(译)	HILL-ROM SERVICES , INC.		
当前申请(专利权)人(译)	HILL-ROM SERVICES , INC.		
[标]发明人	LACHENBRUCH CHARLES A		
发明人	LACHENBRUCH, CHARLES A.		
IPC分类号	A61G7/057 A61B5/00 A61G7/05 A61B5/01 A61B5/103 A47C27/08		
CPC分类号	A61G7/05769 A61B5/002 A61B5/01 A61B5/1036 A61B5/447 A61B5/6891 A61B5/6892 A61B2560/0242 A61B2562/0247 A61B2562/029 A61G7/05 A61G7/0525 A61G7/05738 A61G7/05746 A61G7/05776 A61G7/05784 A61G7/05792 A61G2203/32 A61G2203/34 A61G2203/46		
优先权	61/243622 2009-09-18 US		
其他公开文献	EP2901994B1		
外部链接	<a href="#">Espacenet</a>		

摘要(译)

患者支撑表面的控制系统计算作为压力和剪切的函数的表面性能指数。控制系统还接收来自电子病历 (EMR) 的信息, 该电子病历对应于人的压疮和表面病变中的至少一个的易感性, 并且基于人体支撑表面的组件和特征中的至少一个进行调整。信息。

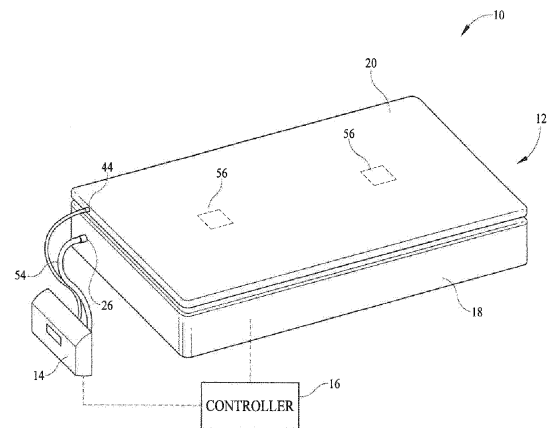


FIG. 1