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(11) **EP 2 893 847 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.07.2015 Bulletin 2015/29

(51) Int Cl.:
A47C 23/043 *(2006.01)*

(21) Application number: **14150690.7**

(22) Date of filing: **09.01.2014**

(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 RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) Smart adjustable bed and method for adjusting of stiffness of a bed in real time

(57) The invention relates to a design for a bed comprising at least one spring block (6,7) with constant firmness, at least one spring block (4,5) with adjustable firmness, measurement means (12) for measuring the pressure on the spring blocks with adjustable firmness, a main controller (8) and a mobile device (9) with a display and control devices, e.g., a smartphone, interactively connected to the bed and the main controller via a wireless communication network. The invention also relates to a method for the automatic adjustment of the softness of the bed depending on the detected sleeping position and prior personalisation of the bed. During personalisation, the softness of the spring blocks with adjustable firmness is adjusted for the user for three pre-determined sleeping positions and the weights falling on spring blocks are measured and used for detecting the sleeping position of the user.

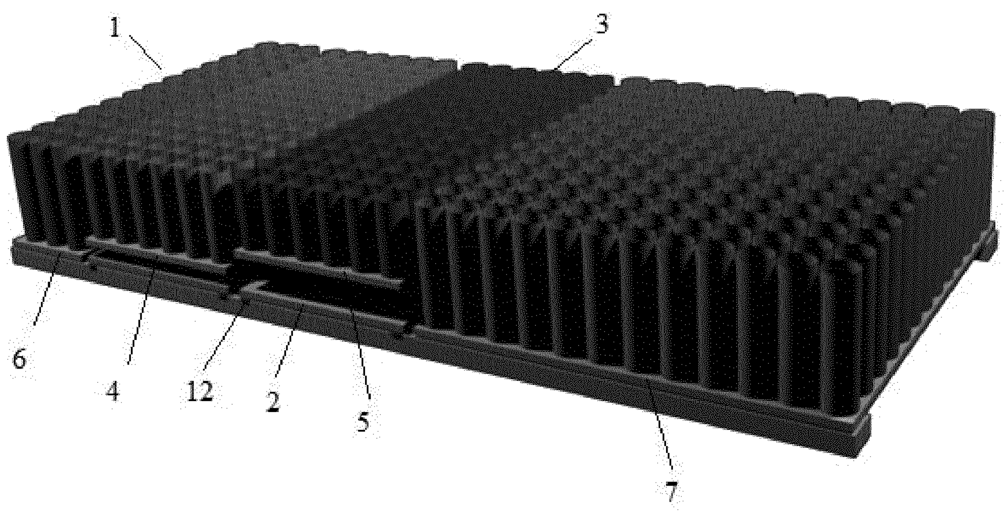

FIG. 1

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Description

Field of the invention

[0001] The invention is related to the field of sleeping equipment, in particular beds, and relates to the automatic or manual adjustment of certain sections of a bed. The automatic adjustment of the firmness of the bed is done based on a prior personalization of the settings of the bed with the help of a portable mobile communication device connected to the main controller of the bed via a wireless communication system, creating firmness profiles of certain sections of the bed for the specific user.

Prior art

[0002] WO2008030981 discloses a digital bed which includes a variety of support elements. Every support element is able to communicate with the controller and increase or decrease its firmness according to the orders received from the controller. The support elements are operatively connected to a communication channel which is also connected with the controller. The controller can receive data from the support elements and also give orders to each support element.

[0003] EP2245967 discloses a furniture device adjusted to receive data about the person's mass, wherein the furniture device includes a section which consists of a base, a plate element, a first set of elastic parts, a multitude of connections, a multitude of connective elements attached to the first elastic parts and the base, and a deformation element which is adjusted to move the plate element. Every elastic part includes an elastic element which has a first spring located in a case. The elastic part has a top and a bottom part, whereas the length of the bottom part can be changed.

[0004] TW201318583 discloses a method and a device which is able to automatically adjust the softness of the mattress according to the sleeping position, whether on the back, on the front or on side. The mattress has a multitude of elastic support units, every one of which consists of a first elastic part and a second elastic part, whereas the second elastic parts move outward from the bottom side of the mattress with the help of the moving device. The elastic support units are equipped with gravity detectors. The gravity detectors and the moving device are connected to the control circuit. The gravity detectors of the mattress determine if the user is lying on their back, front or side.

Summary of the invention

[0005] The object of the invention is to provide a design for a bed which comprises at least one spring block with constant firmness, at least one spring block with adjustable firmness, measurement devices for measuring the pressure on the spring blocks with adjustable firmness, a main controller, and a mobile device with a display and control devices which is interactively connected to the bed and the main controller via a wireless communication network, for instance a smartphone.

[0006] Another object of the invention is to provide a method for the automatic adjustment of the softness of the bed based on the detected sleeping position of the user. In order for the bed to detect the sleeping position and to know what is comfortable for the user, the user must perform a one-time personalisation of the bed. The personalisation is performed with a portable device wirelessly connected with the main controller, e.g., a mobile phone, preferably a smartphone. During personalisation, the softness of the spring blocks with adjustable firmness is adjusted for all three given sleeping positions, taking into account the preferences of the user, and the weight falling on the spring blocks is also measured, and used to determine the sleeping position of the user.

[0007] The bed's main controller and weight sensors detect the user's sleeping position in real time based on the distribution of the user's weight and if a change in the position is detected, whereas this position change lasts for more than a minimum given time period, the firmness of the spring blocks will be adjusted according to the new detected sleeping position. This process is automatic and constant and is performed according to the signals sent from the sleeping position detector to the main controller and commands changing the firmness of the bed issued by the software and controlled by the processor.

[0008] For setting up the device, a test programme is run on the smartphone. The test programme detects whether the communication between the telephone and the bed is working and whether the weights sensors work correctly. When the weight sensors are activated by the test programme, the weight sensors of the bed must indicate changing weights and when pressing on the bed, the weights must change. Before the bed is used, the weight measuring sensors in sections will be calibrated.

List of figures

[0009] A preferred embodiment of the invention is described below in detail, referring to the enclosed figures, where:

FIG. 1 is a schematic general view of the invention without the top cover;

FIG. 2 shows the plate sections of the invention together with weight sensors, the main controller, the mobile device;

FIG. 3 and FIG. 4 show the graphic user interface displayed on the screen of the mobile communication device when creating a connection between the smartphone and the main controller or the bed;

FIG. 5 shows the graphic user interface displayed on the screen of the mobile communication device for starting the personalisation of the bed;

FIG. 6 shows the graphic user interface displayed on the screen of the mobile communication device for manual adjustment of the firmness of the bed sections;

FIGS. 7a to FIG. 7i show the graphic user interfaces displayed on the screen of the mobile communication device for personalising the bed;

FIG. 8 shows the graphic user interface displayed on the screen of the mobile communication device with the user's sleeping position detected by the smart bed;

FIG. 9 shows the graphic user interface displayed on the screen of the mobile communication device for displaying and reading sleeping statistics;

FIG. 10 shows the graphic user interface of the devices displayed on the screen of the mobile communication device;

An embodiment of the invention

[0010] Bed 1 (FIG. 1) comprises sections 3 of springs with adjustable firmness mounted on plate sections 2, whereas the springs are intended for adjusting the firmness of the shoulder area spring block 4 and the hip area spring block 5 according to predetermined parameters. In addition, the bed has two spring blocks with constant firmness - the head area spring block 6 and the legs area spring block 7. The firmness of the section with two adjustable spring blocks can be changed by the main controller 8 (see FIG. 2). The bed is controlled by the user and feedback received via wireless communication using a mobile phone 9, more specifically an Android™ smartphone application, which communicates with the main controller of the bed via, preferably, the Bluetooth™ protocol, e.g., using the Android™ platform. The user controls the bed with a control and monitoring programme in the Android™ smartphone, displayed on the screen of the phone using the user interface 10. The mobile phone and the bed communicate wirelessly over Bluetooth™ or similar protocol. Additionally, the weight of the user falling on the two spring blocks with adjustable firmness is measured.

[0011] In the preferred embodiment, the bed includes four spring blocks, the firmness of two of which - the shoulder area spring block 4 and the hip area spring block 5 - can be adjusted (FIG. 1).

[0012] The bed measures the weight falling on the spring blocks with adjustable firmness 11 with four weight sensors 12 (FIG. 2) per block. The weight sensors are installed in the corners of the spring block 11 and thus the weight falling on the section can be measured regardless of the location of the mass on the block. There are a total of 8 weight sensors per two spring blocks forming 4 weight sensor pairs along the axis of the bed. Since the sensors of two pairs 12 and 12' are very close to each other in the point where the two spring blocks come into contact, these two pairs may be counted as one, calculating the average of the two pairs. Therefore, we can use the indications from three weight sensor pairs as weight data. The weight of the bed user can thus be characterised by three weight measurements.

[0013] Static electricity formed in the bed may substantially influence the work of the electronics of the bed. In order to avoid this, it is advisable to cover the bed with antistatic substance and material or to increase the humidity of the room. Also avoid bed linen that creates static electricity.

Personalisation

[0014] The goal of personalisation is to let the user find the most suitable spring block firmness for him/her in the three predetermined sleeping positions, i.e., on the back, the front and the side, and measure and record in the memory of the main controller all weights of each sleeping position in every state of firmness of the spring blocks. Personalisation results in a 3 x 3 matrix of weight data, where one axis indicates the configuration of spring blocks and the other indicates the sleeping position. This data is constantly used by the sleeping position detector for determining the sleeping position.

[0015] The actual values of weight pairs determined during personalisation are normalised for the axial movement of the user. Personalisation consists of about ten steps (FIGS. 7a to 7i) and the user is instructed to take the positions required for personalisation. During personalisation, your preferences for three sleeping positions (on the back, the side and the front) are recorded. Additionally, during personalisation the bed measures the signals received from the weight sensors to detect the user's sleeping position later on. This results in a 3 x 3 matrix of weight data, where one axis indicates the configuration of spring blocks and the other indicates the sleeping position. This data is used by the sleeping position detector for determining the sleeping position. When the last step in the personalisation process is finished, the bed automatically enters the automatic control mode. Automatic control information should be displayed on the mobile phone screen. After personalisation, the automatic control mode has all the necessary data and begins continuously detecting the user's sleeping position and adjusting the spring blocks. This process is autonomous and the mobile phone bed application does not have to be activated.

[0016] The bed does not react to the user's fast movements in the bed and the user must remain in a new sleeping position for 10 seconds before the firmness of the spring blocks is adjusted.

[0017] When sleeping in a position which is substantially different from the three sleeping positions used by the bed, the bed considers this sleeping position as unknown. When unknown sleeping positions are detected, the firmness of the spring blocks is not changed. The bed can also detect whether anyone is in bed or not. If there is nobody in the bed, the spring blocks will not be adjusted.

[0018] The bed can be controlled manually, if for some reason the user does not want to control the bed automatically. In case of manual control, the firmness settings of the bed's spring blocks will be adjusted to the suitable position with the help of the bed's mobile phone application and after that the bed does not change those settings. It is always possible to go back to the automated control function.

[0019] The actual values of weight pairs determined during personalisation are normalised for the axial movement of the user.

Detecting the sleeping position

[0020] The sleeping position is detected using data obtained from personalisation and the weight data measured by the bed. The bed can be in one out of three sleeping position configurations. The configurations can be characterised by the firmness of the spring blocks set by the user during personalisation.

[0021] In order to use the three weight measurements measured by the weight sensor pairs to detect the user's sleeping position, the measurement results must be normalised according to the possible changes in the position of the sleeper along the axis of the bed. The normalisation constants are derived from the measured weights themselves and the measured weights are corrected using these constants.

[0022] Normalisation constants A for the weight measurements pairs located near the head and legs are calculated by using the weights falling on the two sections as follows:

$$A_{head} = M_{hips} / M_{shoulders}$$

$$A_{legs} = M_{shoulders} / M_{hips}$$

[0023] By using the normalisation constants, we get the new normalised weight pairs:

$$M_{head} = M_{head} * A_{head}$$

$$M_{waist} = M_{waist}$$

$$M_{legs} = M_{legs} * A_{legs}$$

[0024] In order to detect the sleeping position corresponding to the normalised weight pairs, we must compare the normalised weight data with the data measured during personalisation. During personalisation, we have measured weights that correspond to three sleeping positions of all three configurations. The masses of the three weight pairs can be considered as coordinates in space which form one point in this space and the weights obtained from personalisation can also be presented as points in a three-dimensional space. Our aim is to find out which personalisation mass point is the closest to the mass point of the current measurements.

[0025] Calculating distance with the following formula and for all positions:

$$L1 = \mathrm{sqrt}(\ (M_{head} - M_{head\_on\ back})^2 + (M_{waist} - M_{waist\_on\ back})^2 + (M_{legs} - M_{legs\_on\ back})^2\ )$$

$$L2 = sqrt((M_{head} - M_{head\_on\ side})^2 + (M_{waist} - M_{waist\_on\ side})^2 + (M_{legs} - M_{legs\_on\ side})^2)$$

$$L3 = sqrt((M_{head} - M_{head\_on\ front})^2 + (M_{waist} - M_{waist\_on\ front})^2 + (M_{legs} - M_{legs\_on\ front})^2),$$

where:

$$M_{head\_on\ back}, M_{waist\_on\ back}, M_{legs\_on\ back}$$

$$M_{head\_on\ side}, M_{waist\_on\ side}, M_{legs\_on\ side}$$

$$M_{head\_on\ front}, M_{waist\_on\ front}, M_{legs\_on\ front}$$

are the values obtained during personalisation.

[0026] The smallest of the three distances is chosen and this distance identifies the used sleeping position. If the determined smallest distance exceeds a certain predetermined limit, the sleeping position is considered unknown and the configuration of the bed will not be changed.

[0027] The weight falling on two sections must also exceed a small minimum value, otherwise the bed is considered empty.

Automatic bed control

[0028] The automatic bed control function means constantly weighing the user and finding the sleeping position that corresponds to the distribution of the user's weight. Whenever a steady sleeping position is changed, the spring firmness configuration is adjusted to the new position according to the pre-set values. After changing the firmness of the springs, the periodic weighing of the user and detection of the sleeping position starts again.

[0029] The new sleeping position must be stable, before the bed starts changing its configuration. In order to determine the stability of the sleeping position, the new sleeping position must maintain a constant value during for a predetermined time. If the sleeping position has remained unchanged during this time, this sleeping position is regarded as the new sleeping position input for the automatic control function. If the new sleeping position is different from that of the old one, the configuration is adjusted according to the new sleeping position. A new configuration means that the firmness values of the spring blocks that correspond to the new position and that are obtained during personalisation are used to configure the respective blocks. The system uses the firmness values obtained during personalisation and moves the springs of those two sections according to those values.

[0030] Using the graphic user interface of the mobile telephone application, it is possible to display the information of the automatic control function on the statistics page (FIGS 9 and 10) by tapping the option "Your sleeping statistics". The statistics view indicates the duration and number of sleeping positions for different nights.

Claims

1. A smart bed with sections with adjustable firmness, that has a base frame on which the base of spring blocks is located, is **characterised in that** the base of spring blocks is longitudinally divided into different plate sections corresponding to the measurements of the user's body zones, the distance between at least two plate sections and the base of the corresponding spring blocks is adjustable, under the adjustable plate sections are sensors configured to measure the pressure on the plate sections in real time, a main controller configured to carry out the personalisation, detect the user's sleeping position and control the bases of the bed's spring block and to be connected with a portable communication device via a wireless data communication channel.

2. The smart bed with adjustable firmness of claim 1, **characterised in that** the sensors are located in every corner of the adjustable plate section and sensor pairs are thus formed along the axis of the bed.

3. The smart bed with adjustable firmness of claim 1, **characterised in that** the two adjacent sensor pairs of two adjacent adjustable plate sections form one sensor pair.

4. The smart bed with adjustable firmness of claim 1, **characterised in that** there are 3 sensor pairs formed along the bed.

5. The smart bed with adjustable firmness of claim 1, **characterised in that** the portable communication device is a smartphone equipped with a graphic user interface.

6. The smart bed with adjustable firmness of claim 1, **characterised in that** the main controller is configured to detect sleeping positions on the back, the front and side.

7. The smart bed with adjustable firmness of claim 1, **characterised in that** the main controller is configured to record the signals coming from the weight sensors and upon request, display the different measured and calculated data related to the bed and the user on the smartphone screen with the help of the graphic interface.

8. A method for adjusting the firmness of the bed in real time, **characterised in that** it comprises the following stages:

i) personalisation of the bed, during which the user lies on the back, front and side while the plate section weight sensor pairs measure the weights of the three respective positions and data about the weights is obtained;

- normalisation constants are calculated for the weight sensor pairs near the head and legs;
- new normalised data for the weight pairs is obtained;

ii) the user's weight falling on a sensor pair is measured continuously for all weight sensor pairs, this data is then transformed into normalised weight data and the normalised weight data is compared with weight data measured during personalisation;

- the weights of three weight pairs measured by three weight sensor pairs are considered as the spatial coordinates of a mass point defining the location of the mass point in space using three numerical values;
- the location of the closest mass point for positions on the back, the front and side identified during personalisation to the current measurements indicating the location of the mass point in positions on the back, the front and side is determined;
- if the value of the measured weights of the three weight pairs is unchangeable during a predetermined time period, the sleeping position is considered to have changed and the configuration of the firmness of the spring blocks is adjusted according to the new sleeping position;
- the adjusted spring firmness configuration for the new sleeping position is maintained until the change of the value of the measured weights of the three weight pairs is detected again.

9. The method of claim 8 for adjusting the firmness of the bed in real time, **characterised in that** the measured value of the three weight pairs must remain constant for at least 10 seconds.

10. The method of claim 8 for adjusting the firmness of the bed in real time, **characterised in that** the configuration of the firmness of the spring blocks is changed if the measured value of the three weight pairs remains constant for at least 10 seconds.

11. The method of claim 8 for adjusting the firmness of the bed in real time, **characterised in that** if the measured value of the three weight pairs remains below a predetermined value, the bed is considered empty.

12. The method of claim 8 for adjusting the firmness of the bed in real time, **characterised in that** if the location of the current measured mass point of the sleeping position is different from the location of the mass point determined during personalisation by more than a predetermined value, the sleeping position is considered unknown and the configuration of the spring blocks is not changed.

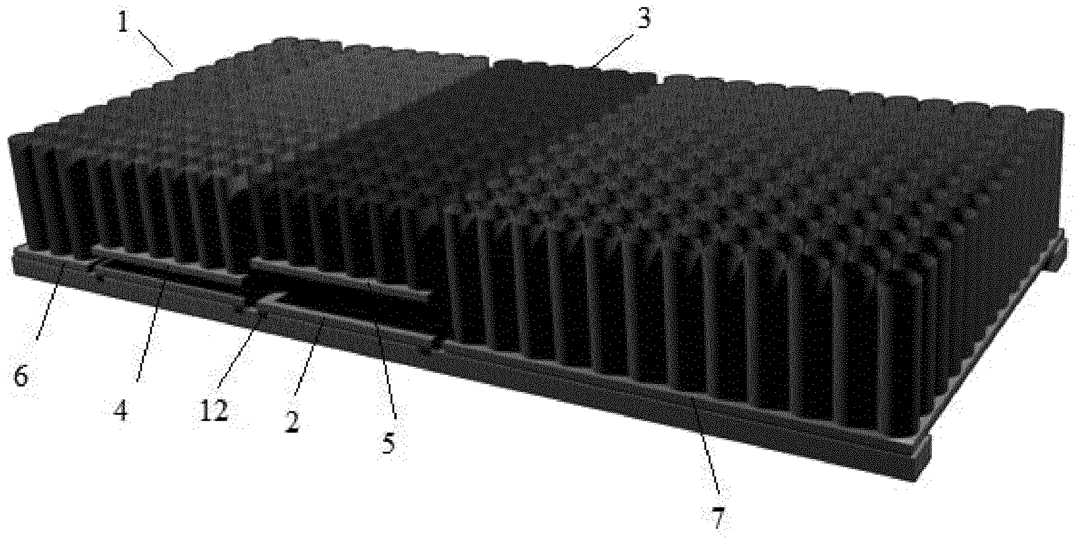

FIG. 1

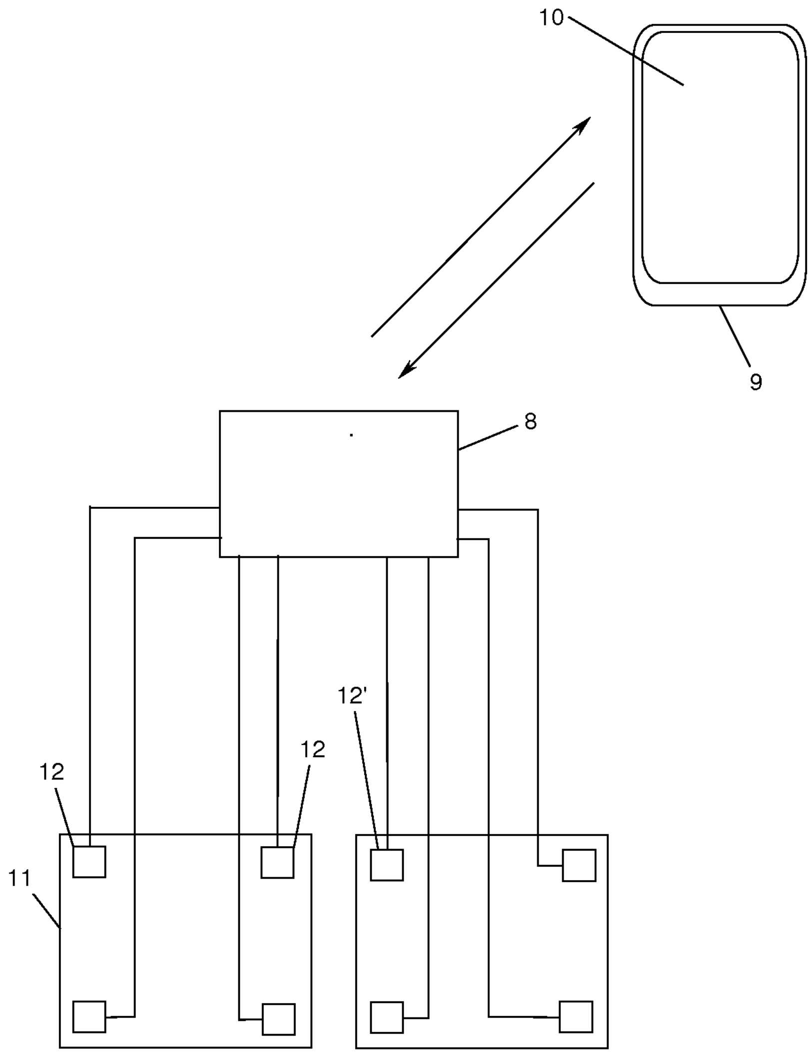

FIG. 2

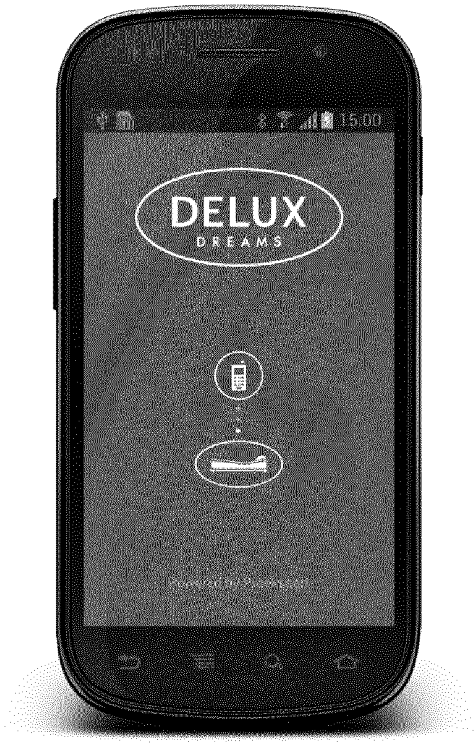
15:00
DELUX
DREAMS
Powered by Proekspert

FIG 4

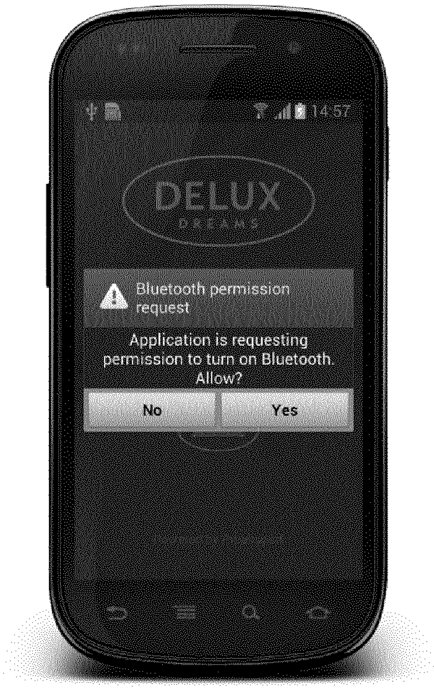
14:57
DELUX
DREAMS
Bluetooth permission request
Application is requesting permission to turn on Bluetooth. Allow?
No
Yes

FIG 3


15:00
DELUX
DREAMS
Please personalize your bed
Smart mode
Manual mode
Powered by Proekspert

FIG 5

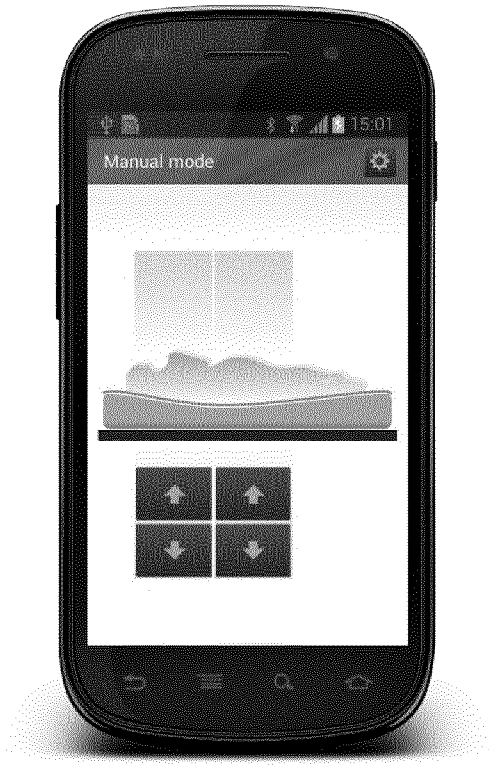
15:01
Manual mode

FIG 6


Personalization
This guide will help you to optimize the bed functionality for your body
Please lay on your back in bed before continuing
Next step
Please adjust the bed to comfortable setup for your back
Please stand still and wait until bed has finished measurement
Please lay on your side in bed before continuing
Please adjust the bed to comfortable setup for your side
Please lay on your stomach in bed before continuing
Please adjust the bed to comfortable setup for your stomach
Your Smart mode personal profile is successfully created

FIG 7a-FIG 7i

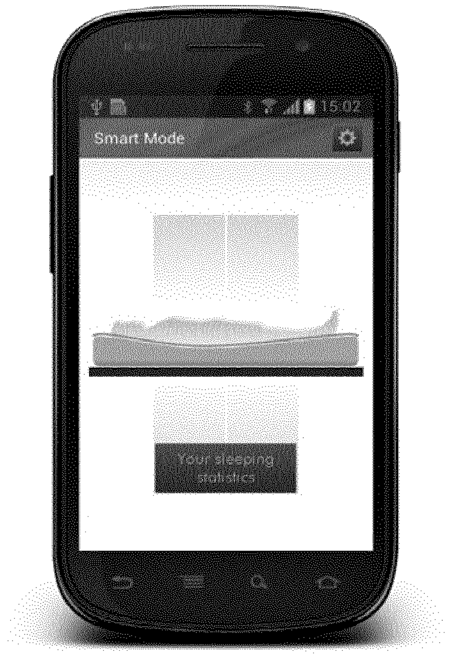

FIG 8

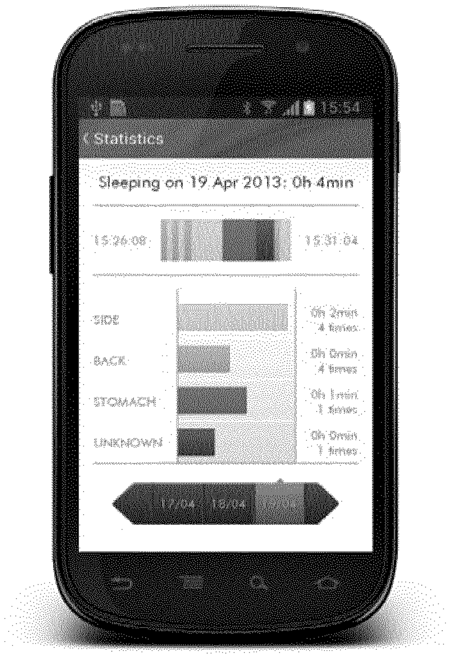

FIG 9

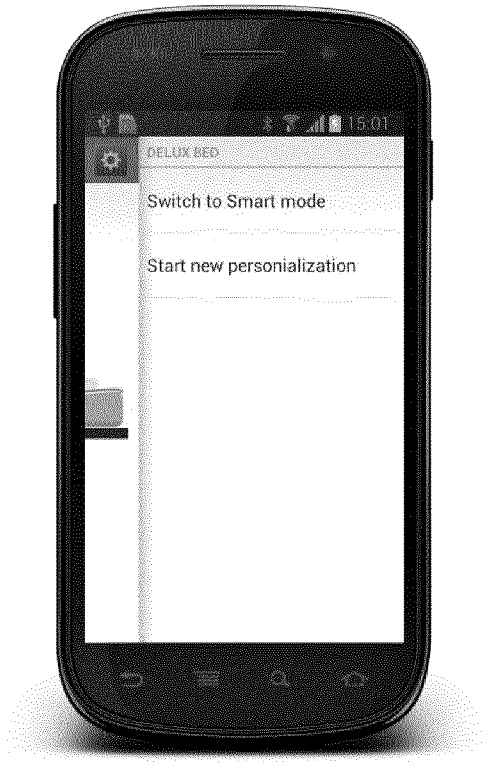

FIG 10

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 0690

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D A	TW 201 318 583 A (XU HAN-ZHONG [TW]) 16 May 2013 (2013-05-16) * page 6, line 12 - page 11, line 2; figures 1-6 * -----	1,5-7 2-4,8-12	INV. A47C23/043
A	US 2008/109965 A1 (MOSSBECK NIELS S [US]) 15 May 2008 (2008-05-15) * paragraph [0030] - paragraph [0049]; figures 1-9 * -----	1	
E	EP 2 745 745 A1 (STJERNFJÄDRAR AB [SE]) 25 June 2014 (2014-06-25) * paragraph [0028] - paragraph [0069]; figures 1-8 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

A47C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 July 2014	Lehe, Jörn

2

CATEGORY OF CITED DOCUMENTS

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08-07-2014

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US 2008109965 A1	15-05-2008	US 2008109965 A1	15-05-2008
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- EP 2245967 A **[0003]**
- TW 201318583 **[0004]**