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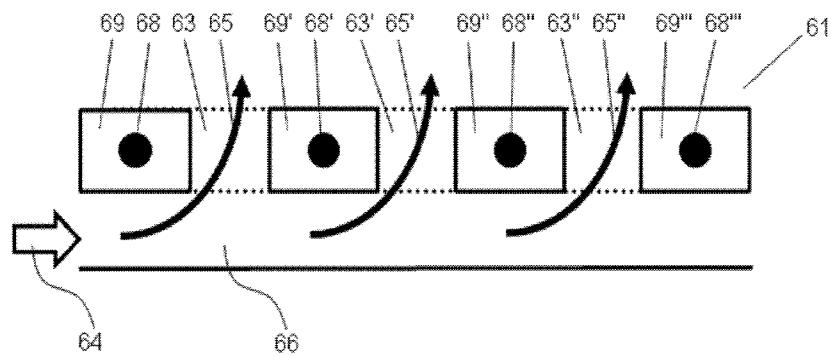


Fig. 3

(57) Abstract: A system for adjusting the microclimate of a bed environment, the system comprising a multi-zone mattress-style support including a plurality of individual heating zones, means for heating the individual heating zones, means for cooling the multi-zone mattress-style support, and a plurality of temperature sensors, wherein the means for cooling the multi-zone mattress-style support comprises at least one air duct within the multi-zone mattress-style support for transporting ambient air through the multi-zone mattress-style support, as well as a method for adjusting the microclimate of a bed environment.

## Temperature-controlled multi-zone mattress-style support

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## FIELD OF THE INVENTION

The invention relates to the field of apparatuses and methods for adjusting the temperature of a bed environment.

## 10 BACKGROUND OF THE INVENTION

Scientific studies have proven that the correct temperature in bed has a positive effect on a person's sleep. An independent study revealed significant improvements in sleep when the consumer's skin was slightly increased in temperature relative to the consumer's skin without temperature manipulation. Raymann et al., (Brain (2008), 131, 500-513) showed that subtle feedback control of in-bed temperature can have strong clinical relevance in the management of disturbed sleep especially for the elderly. Inducing a 0.4 °C increase in skin temperature of elderly subjects was sufficient to almost double the proportion of slow wave sleep and to decrease the probability of early morning awakenings from 0.58 to 0.04. A slight increase in bed temperature facilitates the initiation or reinitiation of sleep (Raymann et al., Sleep, Vol. 31, No. 9, pp.1301-1309, 2008).

The results of this study were obtained in that so-called "water pajamas" were used. These "water pajamas" are bodysuits having an impermeable inner layer and an impermeable outer layer, and water circulating between these two layers was kept constantly at a temperature of 35°C. However, such bodysuits are not consumer friendly devices and they are fairly expensive to manufacture.

Electrical blankets as a means for keeping a person warm and cozy are known for decades. The major disadvantage of such electric blankets is the fact that the temperature cannot be controlled in an appropriate manner. Usually a constant power input is applied and for some blankets the power settings can be changed in discrete steps. However, this does not take into account of any other conditions such as, for example, extra blankets on top of the bed, or the room temperature. Consequently, persons using electric blankets often complain about overheating during the night.

In addition, an electric blanket supplies the heat uniformly to the bed and does not distinguish between areas that do not have to be heated and areas that need more heating. Electric blankets having a separate heating zone for the feet of a person exist, but again they have a fixed heating power instead of a temperature control. Furthermore, qualitative and 5 quantitative validation of using only a heating blanket offering constant temperature in bed has revealed that consumers also want a cooling functionality in such a device.

United States Patent Application Publication No. US 2010/0100004 A1 discloses skin temperature measurement in monitoring and control of sleep and alertness. Said publication teaches a method of influencing sleep by subtly manipulating the skin 10 temperature of a sleeping person. It is stated that sleep can best be manipulated by controlling at least one of a proximal and distal skin area depending on the person concerned and the stage of sleep concerned. The method comprises controlling skin temperature in the subject such as to clamp the skin temperature 0.2 to 0.8°C higher as compared to the skin temperature of the selected portion observed without or prior to manipulation, typically under 15 normal sleeping circumstances. The thermal sleep treatment should preferably aim at individualized and time-of-night dependent control of skin temperature within predetermined ranges during sleep. For slight manipulation of sleep an arrangement is suggested comprising one or more temperature sensors and one or more temperature manipulating units, for instance in the form of one or more cooling elements and one or more heating elements. The 20 temperature sensors may be implemented as a grid of miniature temperature sensors that are integrated in the bed beneath and/or above the sleeping person. The temperature control unit can be implemented in many different ways, for example with thermo-electric devices for heating and cooling, or by control of valves of a tubing system through which temperature-conditioned gas or liquid is circulated.

United States Patent US 6,855,158 B2 teaches a thermo-regulating patient support structure comprising a plurality of air bladders defining a plurality of control zones, each of the plurality of air bladders having an air inlet and an air outlet, a plurality of temperature sensors, wherein at least one temperature sensor is coupled to each of the plurality of control zones, a circulator coupled to the air bladders and configured to move air 30 from the air outlets to the air inlets, a temperature modulator coupled to the air bladders and configured to alter the temperature of air moved by the circulator, and a controller coupled to the circulator, the temperature modulator and the temperature sensors to control the temperature in each of the plurality of control zones based on the output signals from the temperature sensors.

Commercial products that offer both cooling and heating of a bed are available, for example under trade names AmbiSleep and Chillipad. The AmbiSleep device uses Peltier elements for heating or cooling air to levels below room temperature that is subsequently blown through a topper mattress. Chillipad uses water for heat transfer from a

5 Peltier element in a base unit to a mattress topper which contains tubes for water circulation. The major drawback of these products is again that they only allow the user to set a specific heating or cooling power, and cannot control the temperature in bed while sleeping.

Furthermore, the Peltier elements are not energy efficient, they are expensive, large and need fans for having its operation controlled which results in excessive noise.

10 In most cases cooling of the air to below ambient temperature is not needed because the difference between the bed and the ambient temperature is large enough to get a cooling effect by the air flow in the bed.

## SUMMARY OF THE INVENTION

15 It is a first object of the invention to provide a system for adjusting the microclimate of a bed environment to improve a person's sleep.

It is a further object of the invention to provide a method for adjusting the microclimate in a bed environment, and thereby improving a person's sleep.

20 In still another aspect, the invention pertains to the use of a system for adjusting the microclimate of a bed environment for improving a person's sleep.

The first object is achieved by a system that can heat and cool the bed environment based on the temperature which is measured in the bed and/or the sleeping room.

25 The second object is achieved by cooling and/or heating the bed environment based on the temperature which is measured in the bed environment and/or the sleeping room.

The third object is achieved by using a system that can heat and/or cool the bed environment based on the temperature which is measured in the bed and/or the sleeping room.

30 It is desirable to adjust the microclimate of a bed environment, in particular the temperature of a bed environment such that the sleep of a person sleeping within said bed environment is improved compared to a bed environment wherein the temperature is not adjusted. It is even more desirable that the microclimate of individual zones of the bed

environment, in particular the temperature of said zones can be adjusted independently of each other.

A system according to an illustrative embodiment of the present invention comprises a multi-zone mattress-style support structure, a plurality of temperature sensors for 5 monitoring the temperature of the bed environment in each zone of the mattress-style support structure, means for heating the individual zones of the mattress-style support structure, and means for cooling the mattress-style support structure.

The multi-zone mattress-style support may be implemented as a mattress which may be positioned directly on a slatted frame or a box spring. In another embodiment, 10 the multi-zone mattress-style support may be implemented as a mattress topper that can be laid on top of a conventional mattress, for example between the current mattress of a person and the bedding. Preferably, the multi-zone mattress-style support is based on a polymer foam such as a polyurethane foam or a combination of different polymer foams, i.e. foam made of different polymers and/or foams which differ in properties such as density or 15 elasticity, but being made of the same polymer. The multi-zone mattress-style support may also be configured as an inner spring mattress provided with a plurality of zones on at least one of its two faces.

The multi-zone mattress-style support includes a plurality of individual zones, the temperature of each zone of said plurality of individual zones can be adjusted separately 20 by the heating means. The individual zones in which the temperature can be adjusted individually are designated as individual heating zones. The presence of individual heating zones allows to take into account the different temperatures of a sleeping person's torso and his or her extremities and adjust the bed environment accordingly.

The multi-zone mattress-style support further includes at least one duct for air, 25 the at least one duct comprising an inlet opening and at least one outlet opening. In preferred embodiments, the multi-zone mattress-style support comprises a plurality of ducts, each duct comprising an inlet opening and at least one outlet opening, wherein the inlet openings of the ducts of the plurality of ducts may be joined to form a single inlet opening of the system.

Alternatively or additionally, the outlet openings of the duct or the plurality of ducts, wherein 30 each duct of the plurality of ducts comprises a single outlet opening, may be joined to form a single outlet opening of the system. In embodiments comprising two or more ducts, said ducts may be configured to provide individual zones which are designated cooling zones. The presence of individual cooling zones allows to accounting for the different temperatures of a

sleeping person's torso and his or her extremities and adjust the bed environment accordingly.

In a preferred embodiment, one or more of the at least one air duct comprises a plurality of outlet openings, the outlet openings preferably being arranged to the side of the 5 multi-zone mattress-style support preventing air to enter the bed and creating an air flow in the plane of the multi-zone mattress-style support. This embodiment is advantageous, because air flow might cool down the body of a sleeping person too fast, in particular if said person is sweating, and causes the person to wake up, and this embodiment prevents that air coming from the multi-zone mattress-style support will get in direct contact with the body of 10 the sleeping person.

The heating zones of the multi-zone mattress-style support and the cooling zones of the multi-zone mattress-style support may be implemented as single individual zones, i.e., they are identical and cover the same surface area of the multi-zone mattress-style support. In alternative embodiments, the heating zones and the cooling zones are not identical 15 zones, but they may overlap such that, for example, two or more heating zones cover a cooling zone.

The plurality of temperature sensors measure the temperature of the bed environment in their proximity. The plurality of temperature sensors is arranged such that each zone of the multi-zone mattress-style support includes at least one temperature sensor.

20 This arrangement allows measuring the temperature of each of the individual zones of the multi-zone mattress-style support, preferably of the individual heating zones and/or the individual cooling zones. The temperature sensors are operatively connected to a controller for measuring the actual temperatures of the bed environment and for operating the heating means and/or cooling means.

25 In addition, the system may comprise at least one further temperature sensor which measures ambient air temperature in the sleeping room. Said at least one further temperature sensor is also operatively connected to a controller. The presence of at least one additional temperature sensor for measuring the ambient temperature allows consideration of the ambient temperature for adjusting the microclimate of the bed environment.

30 The heating means may be configured as a plurality of electrical resistance wires, wherein each of the individual heating zones includes at least one electrical resistance wire, the temperature of each of said at least one electrical resistance wires being controllable. The at least one electrical resistance wire of each individual heating zone is operable independently of the at least one electrical resistance wire of any other heating zone

of the multi-zone mattress-style support. In an alternative embodiment, the heating means may comprise integrated heating yarns in a textile forming the upper portion of the multi-zone mattress-style support's envelope. Alternatively, the textile may form an individual layer underneath the upper portion of the multi-zone mattress-style support's envelope.

5 Regardless of whether the textile, including the integrated heating yarn forms part of the multi-zone mattress-style support's envelope or an individual layer underneath the upper portion of the multi-zone mattress-style support's envelope, said textile is configured to form individual heating zones which can be heated individually.

In embodiments wherein the system is configured as a twin size (approx. 160 cm x 200 cm), queen size (approx. 180 cm x 200 cm) or king size (approx. 200 cm x 200 cm) mattress or as a topper mattress fully covering the twin size, queen size or king size mattress, it is preferred that each half of the multi-zone mattress-style support in longitudinal direction comprises individual heating zones. Hence, the right half of the multi-zone mattress-style support includes a plurality of individual heating zones, and the left half of the multi-zone mattress-style support comprises a plurality of individual heating zones. This configuration has the advantage that the bed environment, in particular the heating, can be individually adjusted for two individuals sleeping in the same bed at the same time.

The cooling means comprise at least one air duct within the multi-zone mattress-style support. In one embodiment, the cooling means comprises a single air duct, 20 said air duct extends under substantially the entire upper surface area of the multi-zone mattress-style support. In alternative embodiments, the cooling means comprise a plurality of air ducts, said plurality of air ducts extending under substantially the entire upper surface area of the multi-zone mattress-style support.

In an additional alternative embodiment, the cooling means comprising a 25 plurality of air ducts is configured to form individual cooling zones. When the system is configured as a twin size (approx. 160 cm x 200 cm), queen size (approx. 180 cm x 200 cm) or king size (approx. 200 cm x 200 cm) mattress or as a topper mattress fully covering the twin size, queen size or king size mattress, it is preferred that the cooling means comprises at least two cooling zones, a first cooling zone and a second cooling zone, wherein each of the 30 cooling zones represents one half of the multi-zone mattress-style support in a longitudinal direction. Hence, the first cooling zone represents the right half of the multi-zone mattress-style support, and the second cooling zone represents the left half of the multi-zone mattress-style support. This configuration has the advantage for the bed environment, in particular the

cooling, can be individually adjusted for two individuals sleeping in the same bed at the same time.

The cooling means may further comprise at least one fan for blowing air into or sucking air out of the air duct(s). The at least one fan is preferably arranged in the system such that no air can escape from the exit of the fan before entering the at least one air duct. For example, the at least one fan can be arranged within an air duct or in an aspiration port for a plurality of air ducts. The at least one fan is configured such that its operation does not cause noise which would impair a person's sleep when sleeping in close vicinity of the at least one fan. The at least one fan may be located at the head end or at the foot end of the multi-zone mattress-style support. In case of a plurality of fans, all fans may either be located at the same end or the same side of the multi-zone mattress-style support. Alternatively, the fans or the plurality of fans may be located at multiple end or sides of the multi-zone mattress-style support. The at least one fan transports ambient air into the air duct(s). The ambient air is not actively cooled (i.e., cooled to a level below bed room temperature) before being provided to the air duct(s). Usually the ambient air has a lower temperature than the bed environment underneath a sleeping person's blanket. Therefore, cooling the bed environment is considered as "passive cooling". The at least one fan is operatively connected to a controller.

In another embodiment, the cooling means comprises means for lowering the temperature of the air that will be blown through the at least one air duct below ambient temperature, i.e. below the bed room temperature. This type of cooling is considered as "active cooling". The means for lowering the air below ambient temperature may be selected from the group consisting of Peltier elements and cooling compressor units. This embodiment has the advantage, that the microclimate of the bed environment can be adjusted within a larger range of temperatures compared to passive cooling. The at least one means for lowering the temperature of the air that will be blown through the at least one air duct below ambient temperature is operatively connected to a controller. In the embodiment, at least one fan is present which forces the air being subject matter to active cooling through the at least one air duct.

The heating means and the cooling means are separate means, i.e., the heating means are not configured to be the cooling means too, and vice versa.

The plurality of electrical resistance wires or the plurality of textiles comprising integrated heating yarns of the heating means, and the air ducts of the cooling means can be integrated into the multi-zone mattress-style support in several ways. In an

embodiment, the electrical resistance wires are located in a layer on top of a layer comprising the air ducts. The top layer including the electrical resistance wires is made of an open structure such that the cooling air can pass through said top layer. In an alternative embodiment, the air cooling layer is placed on top of the layer comprising the electrical

5 resistance wires. In this embodiment, the top layer is configured such that the air can transport the heat which is generated in the layer beneath to the top surface of the multi-zone mattress-style support. In still another embodiment, the multi-zone mattress-style support comprises a first face having the heating zones as a layer underneath the surface of this face, and a second face on the opposite side of the first face, said second face having the cooling 10 zones as a layer underneath the surface of this second face. This embodiment allows the user to have the cooling side on top in the summer time, and to turn the multi-zone mattress-style support upside down such that the heating side is on top in the winter time.

In another embodiment, the air flow is in contact with the electrical resistance wires. This 15 way the air can be heated in the topper to assist in the heat transfer into the bed. Also this way, the amount of moisture that can be taken up in the air flow through the topper can be increased which will help in drying the bed and removal of body fluids (sweat) from the bed environment.

The system further comprises a controller for receiving the signals from the plurality of temperature sensors, and operating the heating means and the at least one fan of 20 the cooling means. Said controller may be configured to switch-off the heating when a maximum temperature is reached. Thereby additional safety is provided for the user of the system, i.e., the sleeping person.

The system of the present invention permits to adjust the microclimate of a bed environment while a person is sleeping in the bed, and to provide optimal temperature for 25 an improved sleep taking into account the temperature of the bed environment in separate zones, optionally the ambient temperature in the sleeping room, and to increase or reduce the temperature in individual zones of the bed environment.

The system as described herein above can be used to adjust the microclimate of a bed environment. Adjusting the microclimate of a bed environment can improve the 30 sleep of persons when sleeping in the adjusted microclimate compared to sleeping in a non-adjusted microclimate. According to a preferred embodiment, the system of the present invention can be used to adjust the microclimate of a bed environment to a temperature of between 26°C and 36°C, which turns out to be the optimal temperature range for improving a person's sleep. In an additional embodiment, the system can be used to pre-warm the bed

such that the comfort is increased when a person enters the bed for sleeping. In another or additional embodiment, the system can be used to set different temperatures for the time between entering the bed and the time falling asleep, after which the control of the microclimate takes over. In the morning, the system can also be used to change the 5 temperature of the bed environment for waking up the sleeping person.

The present invention also provides a method for adjusting the microclimate of a bed environment for improving a person's sleep, and a method for improving a person's sleep by adjusting the microclimate of the bed environment said person is sleeping in.

The methods comprise measuring the temperature of the bed environment in 10 individual zones, and adjusting the temperature of the bed environment in the individual zones such that the temperature in said individual zones is kept at a preferred, preset temperature. The temperatures of the individual zones are adjusted in that the individual zones are warmed or cooled to the preset temperature. Said preset temperature is preferably in a range of between 26°C and 36°C. Warming is performed in that at least one electrical 15 resistance wire in each individual heating zone is subjected to an electric current thereby becoming warm. The warmth is conducted from the electrical resistance wire through the layer or layers between said electrical resistance wire and the upper face of a multi-zone mattress-style support by conduction. The chill is provided in that air is forced to flow through at least one air duct within the multi-zone mattress-style support. If the air flow is 20 combined with heating at the same time, moisture removal from the bed will be increased due to the diffusion of moisture through the topper into the warm air. Also heat exchange with the person in bed will be increased due to convection.

The ambient air may be the air of the sleeping room where the multi-zone mattress-style support is placed. However, the ambient air may be obtained from an 25 environment outside the sleeping room where the multi-zone mattress-style support is placed, for example, air from outside a building that can be acquired via a pipe or tube.

In an embodiment of the method, the temperature of the air that is forced through the at least one air duct within the multi-zone mattress-style support is not lowered below the temperature of the ambient air, i. e. the temperature of the air in the bed room. 30 Forcing air through the at least one air duct within the multi-zone mattress-style support, wherein the temperature of the air that is forced through the at least one air duct is not lowered below ambient air temperature, can be performed by using one or more fans.

In an alternative embodiment of the method, the temperature of the air that will be forced through the at least one air duct within the multi-zone mattress-style support is

lowered below the temperature of the ambient air, i. e. the temperature of the air in the bed room. The temperature of the air which shall be forced through the at least one air duct can be lowered below ambient air temperature by means which are for example selected from the group consisting of Peltier elements and cooling compressor units. This embodiment of the 5 method further utilizes at least one fan for forcing the air having a temperature below ambient air temperature through the at least one air duct.

The present invention further extends to the use of the system for adjusting the microclimate of a bed environment. More specifically, the invention extends the use of the system for controlling the moisture in the bed environment. In particular, using heating by 10 means of electrical resistance wires in combination with air flow enhances and improves control of moisture in the bed environment. Hence, the present invention also comprises a method for controlling the moisture in a bed, the method comprises using a combination of heating the bed environment by means of electrical resistance wires, and providing an air flow in the bed environment. As the human body loses 0.25 to 0.5 litre each night, controlling 15 the moisture in the bed environment will extend the lifetime of the mattress and also improve the hygiene in the bed. Changing temperature of air will allow the air to take up more moisture (humidity). This will result in a higher flux of water out of the bed into the flowing air.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1A shows a schematic longitudinal section of and illustrates the air flow 25 through one embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 1B shows a schematic longitudinal section of and illustrates the air flow through another embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 2A shows a schematic top view of and illustrates the air flow through one 30 embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 2B shows a schematic top view of and illustrates the air flow through another embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 2C shows a schematic top view of and illustrates the air flow through another embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 2D shows a schematic top view of and illustrates the air flow through another embodiment of the system for adjusting the microclimate in a bed environment.

Fig. 3 is a more detailed representation of a longitudinal section of an embodiment of the system for adjusting the microclimate in a bed environment.

5 Fig. 4 is a more detailed representation of a longitudinal section of another embodiment of the system for adjusting the microclimate in a bed environment.

## DETAILED DESCRIPTION OF EMBODIMENTS

Figure 1A shows a schematic representation of an embodiment of the multi-zone mattress-style support in a longitudinal section. The multi-zone mattress-style support 1 comprises an inlet opening 2 and an outlet opening 3 of an air duct 6. The inlet opening 2 and the outlet opening 4 are positioned at opposite ends of the multi-zone mattress-style support 1. Arrow 4 indicates the flow direction of air entering the air duct 6 at its inlet opening 2, whereas arrow 5 indicates the flow direction of the air leaving the air duct 6 at its outlet opening 3. In this embodiment, the air is transported unidirectional through the air duct 6 within the multi-zone mattress-style support 1. The air is ambient air and cools the multi-zone mattress-style support 1 when its temperature is lower than the temperature of the bed environment above the multi-zone mattress-style support 1.

Figure 1B shows a schematic representation of another embodiment of the multi-zone mattress-style support in a longitudinal section. The multi-zone mattress-style support 11 comprises an inlet opening 12, an air duct 16 and a plurality of outlet openings 13, 13' and 13" at the top face of the multi-zone mattress-style support 11. When ambient air enters the multi-zone mattress-style support 11 via inlet opening 12 as indicated by arrow 14, and is transported through air duct section 16 to exit said air duct 16 at the plurality of outlet openings 13, 13' and 13". The cooling can be improved in that the ambient air is blown through the upper face of the multi-zone mattress-style support 11. Moreover, cooling can be focused on individual zones, namely on zones comprising at least one outlet opening of the plurality of outlet openings 13, 13' and 13".

Referring to Figures 2A to 2D, different embodiments of multi-zone mattress-style supports are shown in elevated views which illustrate various implementations of air ducts and/or zones. Figure 2A shows a multi-zone mattress-style support 21 comprising an inlet opening 22 at a first end of an air duct section 26, and an outlet opening 23 at the other end of the air duct section 26, 26', wherein said inlet opening 22 and said outlet opening 23 are located at the same end of the multi-zone mattress-style support 21. Hence, the air duct

section 26, 26' is configured to make a U-turn and a first portion 26 of the air duct section is separated from a second portion 26' of the air duct section by a separating wall 27. Hence, ambient air can enter the multi-zone mattress-style support 21 in that it is blown into the air duct section 26, 26' through inlet opening 22 as indicated by arrow 24. The air is blown 5 through the first portion 26 and the second portion 26' of the air duct section 26, 26' to exit the multi-zone mattress-style support 21 through outlet opening 23 as indicated by arrow 25.

Figure 2B represents another embodiment of the multi-zone mattress-style support, wherein the multi-zone mattress-style support 31 comprises an air duct section 36, 36', 36", an inlet opening 32 and two outlet openings, a first outlet opening 33 and a second 10 outlet opening 33'. The inlet opening 32, the first outlet opening 33 and the second outlet opening 33' are located at the same end of the multi-zone mattress-style support 31. The air duct section comprises a first portion 36, a second portion 36' and a third portion 36", wherein the second portion 36' and the third portion 36" of the air duct section result from a bifurcation of the first portion 36 of the air duct section such that the flow direction in the 15 second portion 36' and the third portion 36" of the air duct section is opposed to the flow direction in the first portion 36. The first portion 36 of the air duct section is separated from the second portion 36' of the air duct section by a first separating wall 37, and is separated from the third portion 36" by a second separating wall 37'. Hence, the first portion 36 of the air duct section is flanked by the second portion 36' and the third portion 36" of the air duct 20 section. Ambient air is forced to enter the first portion 36 of the air duct section via inlet opening 32 as represented by arrow 34. The air migrates to the end of the multi-zone mattress-style support 31 which is opposite the inlet opening 32 and the outlet openings 33 and 33', and then migrates back to the end of the multi-zone mattress-style support 31 where the inlet opening 32 and the outlet openings 33 and 33' are located. This embodiment has the 25 advantage that the medial section of multi-zone mattress-style support 31 corresponding to the first portion 36 of the air duct section is provided with cooler air than the flanking sections of the multi-zone mattress-style support 31 which correspond to the second portion 36' and the third portion 36" of the air duct section respectively. Usually the torso of a sleeping person is located in the medial section of a mattress, and the arms and legs are lying 30 next to the torso in regions corresponding to the flanking sections of the multi-zone mattress-style support 31.

Figure 2C represents still another embodiment of the multi-zone mattress-style support. The multi-zone mattress-style support 41 comprises a plurality of air duct sections 46, 46', 46", 46''' which proceed unidirectional in a longitudinal direction of the multi-zone

mattress-style support 41 and are positioned essentially parallel to each other. The air ducts are separated from each other by individual separating walls 47, 47', 47''. Each air duct section 46, 46', 46'', 46''' has an inlet opening 42, 42', 42'', 42''' at one end and an outlet opening 43, 43', 43'', 43''' at its opposite end. Ambient air is blown into each of the plurality 5 of air duct sections 46, 46', 46'', 46''' through the respective inlet opening 42, 42', 42'', 42''' and leaves the air duct sections 46, 46', 46'', 46''' at the respective outlet opening 43, 43', 43'', 43''''. The ambient air may be supplied to all the air duct sections 46, 46', 46'', 46''' at one end of the multi-zone mattress-style support 41, or as indicated by arrows 44, 44', 44'', 44''' such that the flow direction of the air through the multi-zone mattress-style support 41 10 occurs in opposite directions with respect to neighboring air ducts.

Yet another embodiment of the multi-zone mattress-style support is shown in Fig. 2D. The multi-zone mattress-style support 51 comprises a plurality of air duct sections 56, 56', 56'', 56''' which proceed unidirectional in a longitudinal direction of the multi-zone mattress-style support 51 and which are positioned essentially parallel to each other. The air 15 ducts are separated from each other by individual separating walls 57, 57', 57''. Each air duct section 56, 56', 56'', 56''' has an inlet opening 52, 52', 52'', 52''' at one end and an outlet opening 53, 53', 53'', 53''' at its opposite end. Ambient air is blown into each of the plurality of air duct sections 56, 56', 56'', 56''' through the respective inlet opening 52, 52', 52'', 52''' and leaves the air duct sections 56, 56', 56'', 56''' at the respective outlet opening 53, 53', 53'', 53''''. The ambient air may be supplied to all the air duct sections 56, 56', 56'', 56''' at 20 one end of the multi-zone mattress-style support 51, or as indicated by arrows 54, 54', 54'', 54''' such that the flow direction of the air through the multi-zone mattress-style support 51 occurs in opposite directions with respect to neighboring air ducts. Instead of proceeding from the head end to the foot end of a multi-zone mattress-style support as is shown in Fig. 25 2C, the air ducts proceed from the left side of the multi-zone mattress-style support 51 to the right side of the multi-zone mattress-style support 51.

Each of the air duct sections shown in any one of Figures 2A to 2D may comprise at least one air duct. Preferably, each of these air duct sections comprises a plurality 30 of air ducts proceeding essentially parallel to each other. Each of the air duct sections shown in Figures 2A to 2C may represent at least one cooling zone or a plurality of individual cooling zones. In addition, each of the air duct sections shown in Figures 2A to 2C may also correspond to at least one heating zone or a plurality of individual heating zones. For example, with reference to Fig. 2D, air duct section 56 representing the air duct section at the head end of the multi-zone mattress-style support 51 may represent a first heating zone of

said multi-zone mattress-style support 51. The air duct section 56' may also represent another heating zone of the multi-zone mattress-style support 51. It is to be understood that each of the air duct sections may also represent a plurality of individual heating zones.

With reference to Figures 3 and 4 suitable assemblies of the multi-zone mattress-style support are illustrated. Fig. 3 displays a portion of a multi-zone mattress-style support 61 in a longitudinal section. The multi-zone mattress-style support 61 comprises an air duct 66 and a layer on top of the air duct 66. The layer on top of the air duct 66 is preferably a layer made of an elastic polymer foam and comprises a plurality of outlet openings 63, 63' and 63" within a polymer foam which is separated into sections 69, 69', 69" and 69''''. Each of the sections 69, 69', 69" and 69'''' comprises an electrical resistance wire 68, 68', 68" and 68'''', wherein the electrical resistance wires proceed perpendicular to the air duct 66. It is to be understood that one or more additional layers may be placed on top of the layer comprising the sections 69, 69', 69" and 69'''' and the outlet openings 63, 63' and 63". Said at least one additional layer may be a thin layer of an elastic polymer foam or a woven textile.

Upon heating, the electrical resistance wires are subjected to an electrical current and become warm. The warmth will migrate through the polymer foam to the top of the multi-zone mattress-style support 61 and warm up the bed environment until a preset temperature is achieved. When the bed environment is to be cooled, ambient air is blown into the air duct 66 as indicated by arrow 64. The air flowing through air duct 66 will leave the multi-zone mattress-style support 61 through the plurality of outlet openings 63, 63' and 63" as indicated by arrows 65, 65' and 65" thereby reducing the temperature of the bed environment.

Figure 4 illustrates another embodiment of assembling the multi-zone mattress-style support. The multi-zone mattress-style support 71 comprises a plurality of air ducts 76, 76' and 76" which are separated from each other by separating walls 77 and 77'. The separating wall 77 and 77' are preferably made from a polymeric foam, preferably an elastic polymeric foam. Separating air ducts from one another may also be achieved by spacer material that is compressed at specific locations or by spacer material that has a variable density, or where different locations of the multi-zone mattress style support certain spacer material with different densities, the lower density spacer material forming the air ducts. A plurality of electrical resistance wires 78, 78', 78", 78''' is arranged on top of the plurality of air ducts 76, 76', 76" and separating walls 77, 77'. An additional layer 71, preferably made of an elastic polymer foam, is arranged on top of the plurality of electrical

resistance wires 78, 78', 78", 78""", the plurality of air ducts 76, 76', 76" and the separating walls 77, 77'. The top layer 71 may be covered with an additional layer, for example, a layer made of a woven textile.

Upon heating, the warmth generated by the electrical resistance wires 78, 78', 78", 78"" due to being subjected to an electrical current will pass through layer 71 and warm up the bed environment there above. For cooling, the electrical resistance wires are not provided with electricity, and ambient air is forced to flow through the air ducts 76, 76', 76". The lower temperature of the ambient air in the air ducts 76, 76', 76" will cool down layer 71 and subsequently the bed environment there above.

10 While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

15

## CLAIMS:

1. A system for adjusting the microclimate of a bed environment, the system comprising a multi-zone mattress-style support including a plurality of individual heating zones, means for heating the individual heating zones, means for cooling the multi-zone mattress-style support, and a plurality of temperature sensors, wherein the means for cooling the multi-zone mattress-style support comprises at least one air duct within the multi-zone mattress-style support for transporting ambient air through the multi-zone mattress-style support, the at least one air duct comprising at least one inlet opening and at least one outlet opening.

10 2. The system according to claim 1, wherein the means for heating the individual heating zones is configured as a plurality of electrical resistance wires or a plurality of heating yarns integrated in a textile.

3. The system according to claim 1 or 2, wherein the individual heating zones are configured to be heated individually.

15 4. The system according to any one of claims 1 to 3, wherein the means for cooling further comprises at least one fan and/or at least one means for lowering the air temperature below the temperature of the ambient air, said means are preferably selected from the group consisting of Peltier elements and cooling compressor units..

5. The system according to any one of claims 1 to 4, wherein the means 20 for cooling the multi-zone mattress-style support does not comprise any means for cooling the air to a temperature which is lower than the temperature of the ambient air.

6. The system according to any one of claims 1 to 5, wherein each of the heating zones of the plurality of individual heating zones is provided with at least one temperature sensor of the plurality of temperature sensors.

25 7. The system according to claim 6, wherein the system further comprises at least one additional temperature sensor for sensing the temperature of the room where the system is located.

8. The system according to any one of claims 1 to 7, wherein the system further comprises a controller, the controller being operatively connected with the 30 temperature sensors, the means for heating the individual heating zones, and the means for cooling the multi-zone mattress-style support.

9. The system according to any one of claims 1 to 8, wherein the multi-zone mattress-style support is implemented as a mattress which may be positioned directly on a slatted frame or a box spring, or as a topper mattress that can be laid on top of a mattress.

10. The system according to any one of claim 1 to 9, wherein the at least one air duct comprises a plurality of outlet openings, the outlet openings preferably being arranged facing the upper face of the multi-zone mattress-style support.

11. The system according to any one of claim 1 to 9, wherein the at least 5 one air duct comprises a plurality of outlet openings, the outlet openings preferably being arranged to the side of the topper preventing air to enter the bed and creating a air flow in the plane of the multi-zone mattress-style support.

12. The system according to any one of claims 1 to 10, wherein a plurality of air ducts is configured to provide individual zones that can be cooled 10 independently of one another.

13. Use of a system as defined in any one of claims 1 to 11 for adjusting the microclimate of a bed environment.

14. A method for adjusting the microclimate of a bed environment, the method comprising the steps of measuring the temperature of the bed environment in 15 individual zones, and adjusting the temperature of the bed environment in the individual zones such that the temperature in said individual zones is kept at a preset temperature, wherein the temperatures of the individual zones are adjusted in that the individual zones are warmed or cooled to the preset temperature, the warming being performed in that at least one electrical resistance wire in each individual heating zone of a multi-zone mattress-style 20 support is subjected to an electric current thereby becoming warm, and the warmth being conducted from the electrical resistance to the upper face of the multi-zone mattress-style support by conduction, and the cooling is provided in that air is forced to flow through at least one air duct within the multi-zone mattress-style support .

15. The method according to claim 14, wherein the temperature of the air 25 that is forced through the at least one air duct within the multi-zone mattress-style support is not lowered below the temperature of the ambient air.

16. The method according to claim 14, wherein the temperature of the air that is forced through the at least one air duct within the multi-zone mattress-style support is lowered below the temperature of the ambient air.

30 17. Use of heating by means of an electrical resistance wire in combination with air flow to enhance moisture control in the bed environment.

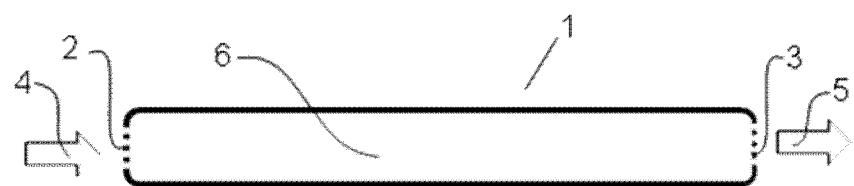


Fig. 1A

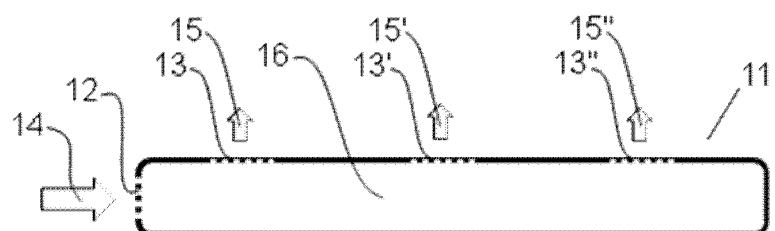


Fig. 1B

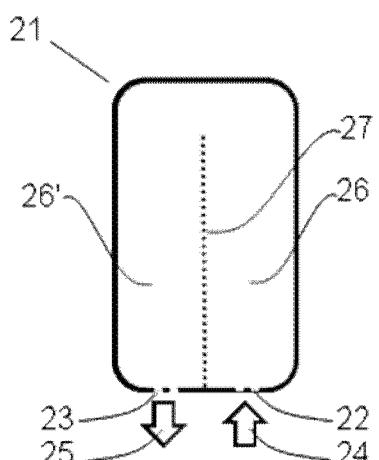


Fig. 2A

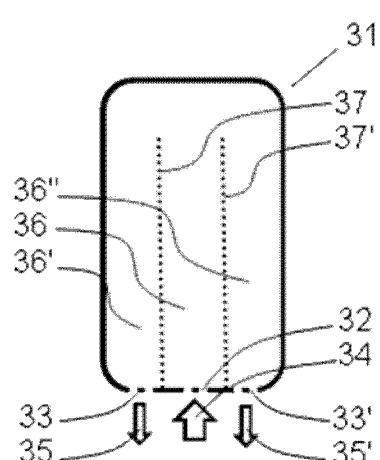


Fig. 2B

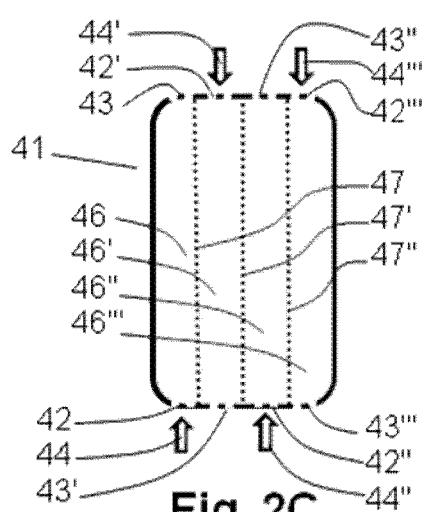


Fig. 2C

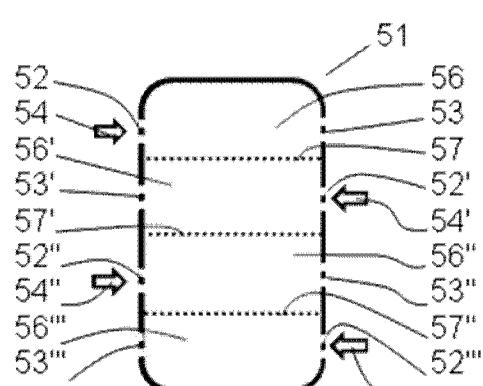
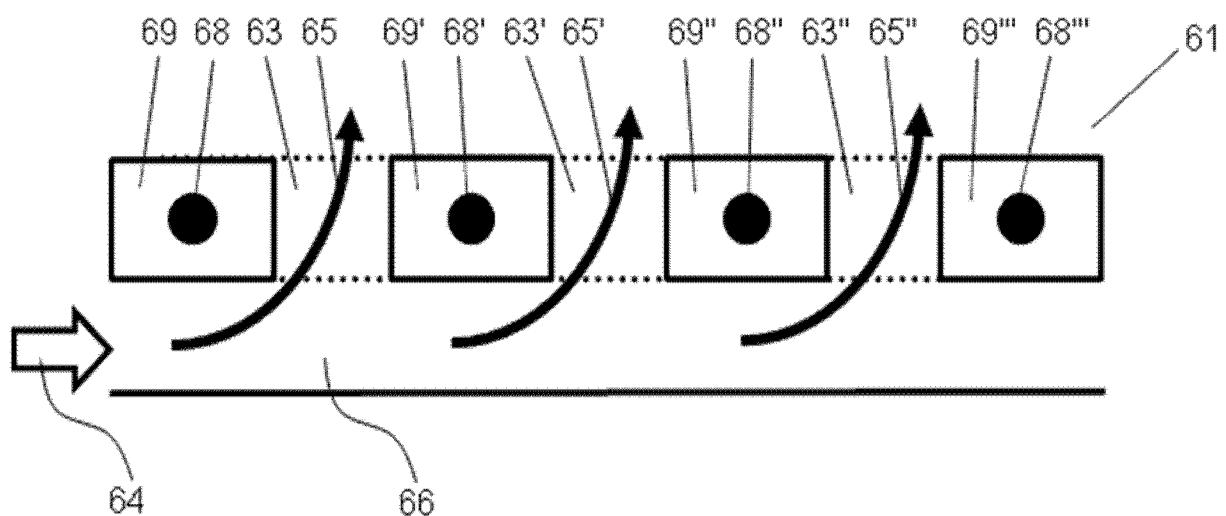
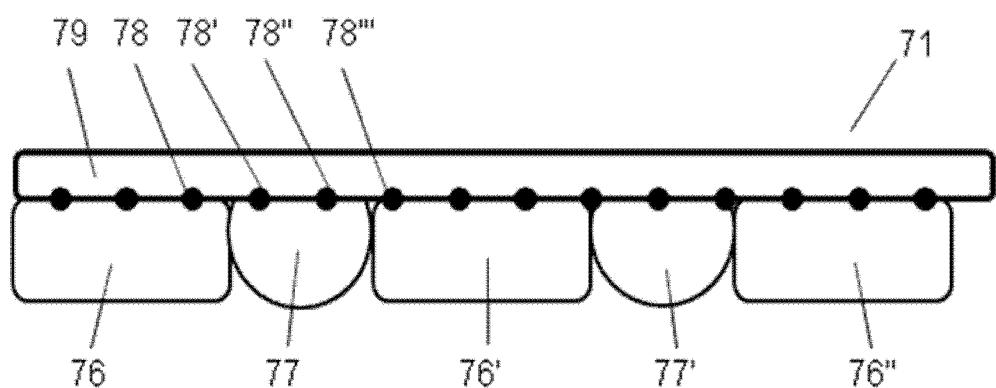


Fig. 2D



**Fig. 3**



**Fig. 4**

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2012/052532

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61F7/00 A47C21/04  
ADD.

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
A61F A47C A61B

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

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

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/022190 A2 (HILL ROM SERVICES INC [US]) 20 March 2003 (2003-03-20) figures 1a,2a,3-9 page 9, line 29 - page 10, line 19 -----	1-4,6, 8-12
X	US 2011/041246 A1 (LI GENG [CN] ET AL) 24 February 2011 (2011-02-24) figures 1,5a,6a paragraph [0042] paragraph [0051] -----	1,2,4, 7-9
X	US 2001/020303 A1 (ENDO TATSUO [JP] ET AL) 13 September 2001 (2001-09-13) figures 1-17 paragraph [0044] - paragraph [0049] ----- -/-	1-3,5,6, 9,10,12

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance  
"E" earlier application or patent but published on or after the international filing date  
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 August 2012	27/08/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Cornelissen, P

## INTERNATIONAL SEARCH REPORT

International application No PCT/IB2012/052532
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## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2006/241730 A1 (HUANG CHARLIE [US]) 26 October 2006 (2006-10-26) figures 3,5,7 paragraph [0061] - paragraph [0063] paragraph [0048] - paragraph [0051] -----	1,2,4,5
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A	WO 99/02074 A1 (VON DER HEYDE CHRISTIAN P [US]) 21 January 1999 (1999-01-21) figure 1 -----	1-12
A	WO 2005/120295 A1 (STATHAM JOHN [GB]) 22 December 2005 (2005-12-22) figures 1-5 -----	1-12

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IB2012/052532

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

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

1.  Claims Nos.: 13-17 because they relate to subject matter not required to be searched by this Authority, namely:  
**Rule 39.1(iv) PCT - Method for treatment of the human or animal body by therapy**
2.  Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3.  Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

#### Remark on Protest

The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2012/052532

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