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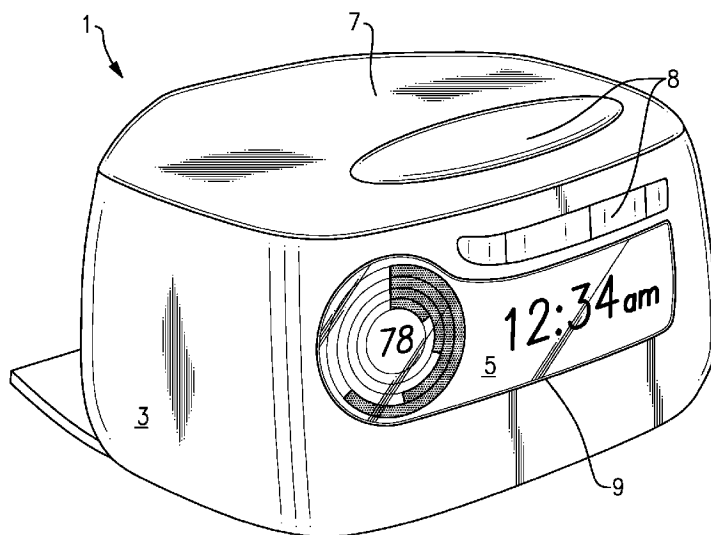


FIG. 1A

(57) Abstract: A sleep assessment device is provided for, including biometric sensors for detecting a heart rate, respiration, or movement of a user. The device detect a user's sleep state by reading signals from the biometric sensor and logs detected information in a sleep record. The device then compares the logged information to a thumbprint of sleep patterns indicative of sleep disorders and outputs an indication of potential sleep disorders based on the comparison.



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SLEEP ASSESSMENT USING A HOME SLEEP SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[01] This application relates to U.S. Patent Application Serial Number 15/267,464 entitled Sleep Quality Scoring and Improvement (Attorney Docket No. B2108-701419); U.S. Patent Application Serial No. 15/267,552 entitled Intelligent Wake-Up System (Attorney Docket No. B2108-701519); U.S. Patent Application Serial Number 15/267,567 entitled Sleep Assistance Device (Attorney Docket No. B2108-701619); U.S. Patent Application Serial Number 15/267,848 entitled Sleep System (Attorney Docket No. B2108-701719); and to U.S. Patent Application Serial Number 15/267,858 entitled User Interface for a Sleep System (Attorney Docket No. B2108-701819); all of which were filed on September 16, 2016 and are incorporated herein by reference.

FIELD

[02] This disclosure relates to systems, methods, and apparatuses for performing sleep assessments using a sleep monitoring device in order to provide sleep assessment information to a user and/or a healthcare professional.

BACKGROUND

[03] Sleeplessness and poor or interrupted sleep may significantly affect a person's health. Poor sleep may be caused by such factors as sleep apnea, sleep walking, sleep talking, and/or snoring. Thus, there exists a need for a device that can monitor sleep patterns for assessing potential sleeping disorders in a user without requiring that the user visit a sleep lab to undergo a study.

SUMMARY

[04] This disclosure relates to systems, methods, and apparatuses for assessing sleep using a sleep monitoring device in order to provide information to users or medical professionals regarding potential sleep disorders detected by the system.

[05] All examples and features mentioned below can be combined in any technically possible way.

[06] In one example of this disclosure, a sleep assessment device is provided for, including at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user; a processor; memory. The processor is configured to detect a user's sleep state by reading signals from said at least one biometric sensor. The processor is also configured to log information in a sleep record, including biometric information detected during the period a user is sleeping. The processor is also configured to compare the logged information in said sleep record to a thumbprint of sleep patterns and output an indication of potential sleep disorders based on the comparison. In some examples, the sleep assessment device may also include a microphone. The thumbprint may also be a thumbprint of a normal sleep pattern or a thumbprint of a known sleep disorder. The sleep disorder may be sleep apnea, sleep talking, sleep walking, or snoring.

[07] In other examples, the processor may also be configured to output a notification of a potential sleep disorder. The sleep assistance device may also include a transmitter for transmitting the notification of a potential sleep disorder. The sleep assessment device may also include at least one direct biometric sensor and the processor may be configured to detect a user's sleep state by reading signals from the at least one direct biometric sensor. In some implementations, the at least one direct biometric sensor may be a blood oxygen sensor. The processor is may also be configured to detect sound while a user is sleeping and log sound information into said sleep record.

[08] A method for providing an indication of a potential sleep disorder is also provided for including the steps of providing at least one contactless biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user; detecting a user's sleep state by reading signals from said at least one contactless biometric sensor; logging information in a sleep record, including biometric information relating to the quality of a user's sleep; comparing the logged information in the sleep record to a thumbprint of sleep patterns; determining whether a potential sleep disorder exists based on the comparison; and providing an indication that a potential sleep disorder exists. In some examples the method may also include providing at least one direct biometric sensor and reading signals from the at least one direct biometric sensor. In some examples, the at least one direct biometric sensor may be a blood oxygen sensor. In some implementations, the method may also include providing at least one microphone; reading signals from the at least one microphone; and logging sound information in the sleep record.

[09] A sleep latency assessment device may also be provided for, including at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user; a processor; and memory. The processor may be configured to detect a user's sleep state by reading signals from the at least one biometric sensor. The processor may also be configured to provide a sleep signal and record the amount of time after the sleep signal is provided before the biometric sensor indicates that the user has fallen asleep. The processor may also be configured to provide an alarm signal a predetermined amount of time after a user has fallen asleep. In some examples, the processor may also be configured to provide at least a second sleep signal after a user has awoken and record the amount of time after the second sleep signal is provided before the biometric sensor indicates that the user has fallen asleep a second time. The processor may also be configured to determine whether additional sleep latency assessment cycles are required based on predetermined sleep latency assessment criteria. In other examples, the processor may also be configured to generate a sleep latency assessment report based on at least one sleep latency assessment cycle.

[10] A method for assisting a user sleep may also be provided, including the steps of providing a sleep assistance device comprising at least one speaker, at least one microphone, a processor, and at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a first user; determining that a first user has fallen asleep based on signals received from the biometric sensor; detecting sounds emanating from the first user through the microphone; determining a noise-masking sound based on the detected sounds emanating from the first user; and playing the noise-masking sound through the at least one speaker for assisting a second user sleep.

BRIEF DESCRIPTION OF THE DRAWINGS

[11] Various aspects of at least one implementation of a sleep assessment system are discussed below with reference to the accompanying figures. The figures are provided for the purposes of illustration and explanation and are not intended as a definition of the limits of the disclosure.

[12] FIG. 1A is a front perspective view of a sleep assessment device with a rectangular housing in one example of the present disclosure.

[13] FIG. 1B is a front perspective view of a sleep assessment device with a cylindrical housing in one example of the present disclosure.

[14] FIG. 1C is a front perspective view of a sleep assessment device with a square housing in one example of the present disclosure.

[15] FIG. 2 is a schematic of the components of a sleep assessment device in one example of the present disclosure.

[16] FIG. 3 is a flowchart showing a potential sequence of steps for a sleep assessment program in one example of the present disclosure.

[17] FIG. 4 is a flowchart showing a potential sequence of steps for a partner noise masking program in one example of the present disclosure.

[18] FIG. 5 is a flowchart showing a potential sequence of steps for a sleep latency assessment program in one example of the present disclosure.

DETAILED DESCRIPTION

[19] It should be understood that the following descriptions are not intended to limit the disclosure to an exemplary implementation. To the contrary, it is intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the described subject matter.

[20] FIGS. 1A-1C are front perspective views of a sleep assessment device 1 in three examples of the present disclosure. As shown, a sleep assessment device 1 may include a housing 3, a display screen 5, speakers 7, and buttons 8 or a touchscreen 9 for inputting information into the sleep assessment device. A wide variety of forms may be utilized for a sleep assessment device, including a rectangular shape (e.g. Fig. 1A), an elongate cylindrical tower (e.g. Fig. 1B), or a flat square shape (e.g. Fig. 1C). However, as one of ordinary skill in the art will appreciate, any suitable form factor may be utilized that may be suitable for being placed nearby a user while sleeping, such as on a night stand, for example. In such examples, housing 3 may be formed into a suitable shape from any rigid materials, including plastics, metals, wood, or composites.

[21] In some examples, a display screen 5 may provide biometric or sleep information gathered by sleep assessment device 1 that may be of interest to a user. Such information may include information regarding the user's biometrics observed during sleep periods, such as

information regarding the user's presence, heart rate, heart rate variability, respiratory rate, ambient temperature, movement, snoring, or sleep state over time. This may be direct information or derived information. In some examples, user interface screen 5 may also include a clock as shown, for example, in FIGS. 1A-1C.

[22] Speakers 7 may comprise any suitable speaker system for generating sounds, as may be familiar to one of ordinary skill in the art. In some examples, speakers 7 may comprise an upwards firing driver along with an acoustic deflector, to provide an omni-directional acoustical experience. Such configurations may be helpful for providing non-directional, room-filling sounds for a soundscape or a white noise while a user is sleeping. Omni-directional sounds systems may be particularly helpful to achieve soothing sounds, a natural wake-up experience, and a consistent listening experience throughout the room. As one of ordinary skill in the art will appreciate, any acceptable sound system for speakers 7 may be employed for producing room-filling sounds, however.

[23] Touchscreen 9 or buttons 8 may comprise any suitable means for delivering inputs to sleep assessment device 1, including a tactile sensor coupled to a surface of housing 3 for detecting the presence of a user's fingers and for detecting pressure, such as when a virtual button on touchscreen 9 is being pressed by a user. Virtual buttons may be displayed on touchpad 9 in a manner familiar to one of ordinary skill in the art in order to allow an operating system to accept input commands from a user. In this manner, sleep assessment device 1 may be configured to accept input commands in a variety of ways and in a variety of contexts, by providing a programmable user interface that may present options and choices to a user via touchpad 9. In other examples, touchscreen 9 may present a permanent display of fixed virtual buttons or include fixed physical buttons 8 for receiving inputs from a user.

[24] In some examples, display screen 5 and a touchscreen 9 may not be necessary or may be reduced in function because a user's smartphone or other external computing device may be used for linking with sleep assessment device 1, displaying information from sleep assessment device 1 and/or accepting inputs and delivering them to sleep assessment device 1 in order to control its functions. In such a configuration, the display screen 5 and touchscreen 9, if any, may display and control only typical bedside clock-related functions, such as time, alarm, and music selection, or a simplified component of the sleep score, such as just a total score value, may be displayed.

[25] FIG. 2 provides an exemplary schematic of a sleep assessment device, showing its components. As shown, sleep assessment device 1 may include one or more main board(s) 13, including a processor 15, memory 11, and interconnects 12. Main board 13 controls the operation of several other connected components, such as a microphone 10, display screen 5, audio amplifier 6, speakers 7, and buttons 8 or a touchscreen 9 for inputting information into the sleep assistance device. Communications hardware 17 may include any wired or wireless communication means suitable for use with a sleep assessment device, such as WiFi, Bluetooth, USB, micro USB, or any suitable wired or wireless communications technologies known to one of ordinary skill in the art. Main board 13 also receives information from biometric sensor 19 as well as any number of environmental sensors 18, for detecting environmental conditions, such as temperature, humidity, ambient light, and air quality. Main board 13 also receives inputs based on a user's interactions with a user interface 14, which may include voice-activated commands detected by microphone 10; various audio, alarm, and sleep control inputs received from buttons 8 or touchscreen 9; or inputs received from a companion application running on a user's smart phone or other external computing device. The communications hardware 17 may also provide communications with external data sources, such as weather reports, and connected home services providing access to such things as lights, thermostat, locks, and any of the sensors 18.

[26] Microphone 10 may be any suitable microphone for detecting and sampling sounds within a user's bedroom or sleep space, as is known to one of ordinary skill in the art. In some examples, microphone 10 may be an arrayed microphone that is suitable for distinguishing between sounds produced by sleep assessment device 1 and sounds produced externally within the user's bedroom or sleep space. In examples where microphone 10 comprises an arrayed microphone, it may comprise a plurality of omnidirectional microphones, directional microphones, or any mixture thereof, distributed about sleep assessment device 1. Microphone 10 may be coupled to processor 15 for simultaneous processing of the signals from each individual microphone in a manner familiar to one of ordinary skill in the art in order to distinguish between sounds produced by sleep assessment device 1 and other sounds within the room and to analyze any external noises for use with sound-masking subroutine 27, as discussed below. Microphone 10 may employ beamforming or other techniques to achieve directionality in a particular direction, for example, towards a sound to be analyzed. Microphone 10 may be

employed both for monitoring the user's sleep and for receiving spoken user interface commands.

[27] Biometric sensor 19 remotely detects information about a nearby user, including bed presence, respiration rate, heart rate, heart rate variability, or a sleep state among other biometric indicators. In some examples, biometric sensor 19 may be a contactless biometric sensor which may use an internal RF sensor for directing RF signals towards a user, measuring the strength of the backscattered signal, and analyzing the backscattered signal to determine the state of various vital signs of a user over time. Other contactless biometric techniques may include lasers for measuring minor skin deflections caused by a user's heart rate and blood pressure; or image-based monitoring systems, whereby skin deflections caused by heartbeats and blood pressure may be observed and analyzed over time through a camera. Biometric sensor 19 may be configured to report detected biometric information to processor 15 for storage in memory 11 and to be analyzed for use in the various subroutines described herein.

[28] In other examples, sleep assessment device 1 may also employ a direct biometric sensor as is known to one of ordinary skill in the art. A direct biometric sensor may include probes or contact pads, that may be disposed on or under the user's body or within their mattress or sheets in order to mechanically detect biometric information, such as movement, respiration, heart rate, blood pressure, and temperature, among others. Such sensors may include accelerometers, other motion sensors, or mechanical sensors such as piezoelectric sensors or other vibration sensors. In other examples, a direct biometric sensor probes may include a blood oxygen sensor (or oximeter). The oximeter may be a sensor that relies on transmissive pulse oximetry and/or reflectance pulse oximetry. The oximeter is useful for detecting a blood oxygen level in a user and for detecting potential hypoxemia in a user. The biometric information detected by the probes may then be communicated to sleep assessment device 1 using a wired or wireless connection in a manner known to one of ordinary skill in the art. In some examples, a biometric sensor may be placed within earbuds worn by a user. Other implementations may combine both contactless and direct biometric sensors. Mechanical sensors that measure the body through an intervening medium, such as bedding, are included in the category of "contactless" biometric sensors.

[29] In some examples, the processor 15 detects a user's sleep state by reading signals from the at least one biometric sensor 19, logs information in a sleep record in memory (or another

storage device) 11, including biometric information relating to the quality of a user's sleep. The processor may also output an assessment of potential sleep disorders based on the logged information in the sleep record. Examples of potential sleep disorders that may be observed by various implementations of the sleep assessment device include sleep apnea, sleep talking (somniloquy), sleep walking (somnambulism or noctambulism), and snoring. As discussed in relation to the systems and methods described below, some implementations of the sleep assessment device may output a sleep assessment that is based on a comparison of the logged information in the sleep record to a thumbprint of a normal or abnormal sleep pattern.

[30] At least one thumbprint of normal sleep patterns or at least one the thumbprint of one or more known sleep disorders can be stored in the memory 11. The computer readable memory 11 can store thumbprints that are sound files, databases, or other files capable of storing information relating to any biometric indicators of a potential sleep disorder, including sounds, respiration signatures, pulse signatures, among others. The thumbprint may include time domain or frequency domain data for comparison to time domain r frequency domain data observed by the at least one contactless sensor or a direct sensor of the sleep assessment device.

[31] In some examples, processor 15 may assess potential sleep disorders based on measured characteristics of a sleep record. For example, the processor may detect periods of increased movement of the user, periods of decreased movement of the user, a length of time between movements of the user, a period of time of irregular respiration, a period of time of no respiration, a period of time of irregular pulse, a period of time of no pulse, or other periods of time during which there is an indicator of disrupted sleep, depending on what sensors are in communication with the processor 15. In some examples, processor 15 may detect periods of decreased blood oxygen levels in implementations where an oximeter is employed as a biometric sensor. When these measured characteristics for a user are consistent with a sleep disorder, the processor 15 may identify the potential sleep disorder in the user and indicate that the user should further investigate whether he or she may be diagnosed with the respective sleep disorder in order to seek treatment.

[32] In some examples, the processor 15 may output a notification of a potential sleep disorder to a user. In such examples, the communications hardware 17 may be in communication with the processor and may transmit the output sleep assessment data to another electronic device. The system, device, and method of this disclosure are each useful for approximating a sleep lab

in the convenience of a user's home. The system and method may also be useful for producing a sleep assessment report for a healthcare professional. This report may be transmitted to a doctor or other healthcare professional at a remote location using the communications hardware 17. Alternatively, a doctor or other healthcare professional may be granted permission to access or download the information stored in a sleep record in memory 11.

[33] In other implementations, the sleep assessment device may provide sleep improvement tips to a user. In such implementations, the system may include a coaching application that sheds light on a user's sleep patterns, identifying both major and minor changes that the user can make to get better rest as disclosed, for example, in U.S. Patent. App. Serial No. 15/267,464 (Attorney Docket No. B2108-701419), the disclosure of which is incorporated herein by reference. In such examples, where sleep assessment device 1 determines that user behaviors either ameliorate or exacerbate a potential sleep disorder, the system may also provide coaching tips to help address a detected sleep disorder.

[34] FIG. 3 shows an example of a method for assessing a user's sleep for potential sleep disorders. At step 1 (box 301 in FIG. 3), a sleep assessment device is provided, including at least one biometric sensor for detecting at least a heart rate of a user, respiration of a user, and movement of a user; a microphone 10 for detecting sounds within a bedroom or sleep space; and a processor 15 coupled to memory 11, which may store information regarding potential sleep disorders, such as a sleep disorder thumbprint, as described above. Each biometric sensor may be a contactless biometric sensor or a direct biometric sensor or a mixture of contactless and direct biometric sensors. In step 2, the sleep assessment device, including the at least one biometric sensor is initialized (box 302).

[35] Once initialized, sleep assessment device 1 may begin taking biometric and environmental readings relevant to a user's sleep state. For example, at step 3, processor 15 reads signals from biometric sensor(s) 19 to determine when a user has achieved sleep (box 303). At step 4, once a user has achieved sleep, processor 15 reads microphone 10 in order to detect sounds produced while a user is sleeping (box 304). Any detected sound information may be logged into a sleep record which may be a database of information recorded or detected by sleep assessment device 1 throughout a sleep session (box 304A). In some examples, the acoustic characteristics of a sound (e.g. pitch, volume, duration) may be recorded in the sleep record. In other examples, the sound itself may be recorded and saved within the sleep record for future

analysis by a user or a healthcare professional. At step 5, processor 15 detects a user's sleep state and information regarding the quality of a user's sleep by reading signals from the biometric sensor(s) 19 (box 305). Data received by processor 15 from the biometric sensor(s) may be logged in a sleep record (box 305A). In some implementations steps 4 and 5 proceed simultaneously in parallel.

[36] At step 6, processor 15 detects whether a user has permanently awoken from sleep, signaling the end of a sleep session (box 306). To do so, processor 15 may continually monitor the biometric readings provided by biometric sensor(s) 19 in order to determine whether a user has awoken or left their bed. If so, processor 15 may continue monitoring biometric information for a predetermined period of time (e.g. 20 minutes) to determine whether the user has returned to sleep. If so, processor 15 may return to steps 4 and 5 until detecting another waking event. Alternatively, if the user does not return to sleep, processor 15 may determine that the sleep session has ended and discontinue readings from biometric sensor 19.

[37] In step 7, processor 15 may be configured to check for potential sleep disorders once the sleep session has concluded, based on the sounds or biometric information logged in the sleep record during the sleep session (box 307). This can be achieved by comparing the logged information to thumbprints of known sleep disorders stored in memory 11, or measuring characteristics of the logged information in the sleep record, as discussed above. In some examples, an assessment of a potential sleep disorder may be based on a comparison between the logged information in the sleep record to a thumbprint of a normal sleep pattern. The thumbprint may be a sample of time domain data or frequency domain data. Where a thumbprint is used, processor 15 may compare at least a subset of the logged information to the normal thumbprint. If there is a match between the logged information and the normal sleep thumbprint the user's sleep may be confirmed as being within normal parameters. If there is not a match between the logged information and the normal sleep thumbprint, the user's sleep may be assessed as abnormal.

[38] In some examples, an assessment of a potential sleep disorder may be based on a comparison of the logged information in the sleep record to an abnormal thumbprint of a known sleep disorder. As described above, the thumbprint of a known sleep disorder may be time domain data or frequency domain data, although any suitable form of a thumbprint may be utilized as is known to one of ordinary skill in the art. Such time domain data or frequency

domain data may reflect biometric information over time known to be an indication of a potential sleep disorder, such as heartrate, respiration rate, detected sound characteristics, movement, or blood oxygen levels, among others, known to be consistent with a sleep disorder. Where an abnormal thumbprint is used, processor 15 may be configured to compare at least a subset of the logged information to the thumbprint of a known sleep disorder. If there is a match between the logged data and the abnormal thumbprint, the user's sleep may be assessed as abnormal or as consistent with a disorder. If there is no match between the two, the user is may be assessed to be an unlikely candidate for the respective sleep disorder.

[39] In some examples, the sleep disorder may be a sleep apnea, sleep talking, sleep walking, or snoring. Other potential sleep disorders may also be assessed, and respective thumbprints may be provided for those additional disorders. In some examples, the method can employ more than one thumbprint, so that the method is capable of assessing a user with a first sleeping disorder based on matching logged data to a first thumbprint, the method is capable of assessing a user for a second sleeping disorder based on matching logged data to a second thumbprint, and the method is capable of assessing a user with a third sleeping disorder based on matching logged data to a third thumbprint, and so on.

[40] The method may further comprise a step 8 for providing a notification of a potential sleep disorder to a user. In some examples, this can be done by displaying the notification on the touchscreen 9 of the device 1. In other examples, this can be done by transmitting the notification to another device, such as a cell phone, a tablet, or another electronic device or to an email address of a user. Step 8 may also include providing notifications that include sleep coaching tips generated by the processor 15 of the device. For example, in step 8, processor 15 may be configured to provide suggestions for changes the user can make to improve his or her sleep or potentially ameliorate the symptoms of a detected potential sleep disorder, and generate suggestions of features of the system that the user can leverage to improve their sleep (box 308).

[41] In some examples, the method may also include step 9 for transmitting the output sleep assessment data through communications hardware 17 to a third party, such as a healthcare professional (box 309). This sleep assessment data may be received by another device, where it can be stored in memory or another storage device, and can be displayed to a user. In other examples, a user's sleep record may be maintained on sleep assessment device 1, but permission for third parties (e.g. a doctor or healthcare professional) to access the information via a network

may be granted by a user. Such information may be useful for a healthcare professional to diagnose a potential sleep disorder or continue to monitor a user's progress during treatment for an already-diagnosed sleep disorder.

[42] Some examples of step 2 of method 200 may include activating sensors for sensing a blood oxygen level of a user (box 302). In such examples, step 5 may include detecting a user's blood oxygen level (box 305). As one of ordinary skill in the art will appreciate, sleep apnea may be indicated by a cessation of breathing along with a 4% drop in blood oxygen level. The processor 15 is capable of identifying such symptoms collected by the biometric sensor(s) that correspond to sleep apnea, and is capable of determining that the user has sleep apnea or potentially has sleep apnea.

[43] In other examples, step 5 may include detecting the number of times that the user awakens during the night (box 305). The number of awakening events can be displayed on the touchscreen 9 of the device 1 and recorded in a user's sleep record for later analysis.

[44] FIG. 4 shows an example of a method for improving the sleep quality of the partner of a user who snores or makes noise during the night, for example, through movement. At step 1, a sleep assessment device is provided, including at least one microphone 10 for detecting sounds within a bedroom or sleep space; and a processor 15 coupled to memory 11, which may be configured to generate noise-masking sounds based on detected noises in a manner known to one of ordinary skill in the art (box 401 in FIG 4). At step 2, a second user, who may be the partner of the first user, is provided with a pair of headphones, or a pair of earbuds, or another set of speakers for directing a masking sound to the partner's ears (box 402). In step 3, the sleep assessment device, including the at least one microphone is initialized (box 403).

[45] At step 4 microphone 10 may detect sounds occurring within the bedroom or sleep space during the night, including noises created by a first user of the device (box 404). At step 5, processor 15 selects a suitable masking noise based on the sounds detected within the room or sleep space, including sounds emanating from the first user (box 405). A masking sound may be a sound such as white noise. At step 6, noise-masking sounds may be played through the sound producing device(s) provided at step 2 (box 406). In some examples, the sound producing device(s) used by the partner may additionally provide noise-cancelling signals, which may be modified according to the noise-masking sounds provided by the sleep system.

[46] FIG. 5 shows an example of a method for performing a sleep latency assessment. In some implementations of the present disclosure, a user's sleep latency may be tested by prompting the user to fall asleep periodically to determine how quickly a user achieves sleep. If a user successfully falls asleep within a predetermined period of time (e.g. 5 minutes) of being prompted, the system wakes the user, and sets another prompt for the following hour. The number of times the user successfully falls asleep can be useful for assessing their overall sleep latency and identifying potential sleep disorders.

[47] At step 1, a sleep assessment device is provided, including at least one biometric sensor for detecting at least a heart rate of a user, respiration of a user, or movement of a user; and a processor 15 coupled to memory 11 (box 501 in FIG. 5). Each biometric sensor may be a contactless biometric sensor or a direct biometric sensor or a mixture of contactless and direct biometric sensors. At step 2, the sleep assessment device, including the at least one biometric sensor, is initialized (box 502).

[48] At step 3, processor 15 provides a sleep signal for indicating to a user that they should now attempt to fall asleep (box 503). In some examples, the sleep signal may be an auditory prompt played by the sleep assistance device, such as one or more tones or a recorded audio instruction to begin trying to fall asleep. In other examples, a sleep signal may take the form of a written announcement appearing on display screen 5 or on another display screen of an external computing device in communication with sleep assessment device 1.

[49] At step 4, processor 15 may begin timing how long it takes for a user to fall asleep (box 504). In some examples, processor 15 may note the time that the sleep signal was provided in a sleep record stored in memory 11. In other examples, processor 15 may start a timer in order to determine how long the user stays awake after receiving the sleep signal. However, any suitable method for tracking the time until a user falls asleep known to one of ordinary skill in the art may be used.

[50] At step 5, processor 15 begins monitoring the sleep state of the user on a continual basis until sleep is achieved (box 505). For example, processor 15 may read one or more biometric sensors 19 that provide a direct indication that a user has lost consciousness. In other examples, biometric sensor(s) 19 may continually monitor and report other biometric information such as a user's heartrate, respiration rate or bodily movement from which a loss of consciousness may be deduced in a manner known to one of ordinary skill in the art. Once a user has been detected

falling asleep, processor 15 may record the time that the user has fallen asleep or the elapsed time since the sleep signal was provided in a sleep record stored in memory 11 (box 505A).

[51] At step 6, processor 15 may determine whether sufficient latency assessment cycles have been performed based on pre-set criteria (box 506). For example, processor 15 may continue the sleep latency assessment until a user has achieved sleep a prescribed number of times.

Alternatively, processor 15 may continue the sleep latency assessment for a certain amount of time or until a desired time of day. If processor 15 determines that the sleep latency assessment should continue then the processor 15 may trigger an alarm tone at step 6A (box 506A). At step 6A, processor 15 may wake the user after a pre-determined amount of sleep (e.g. 5 minutes) in order to test the user's ability to fall asleep again. Any suitable mechanism for waking the user may be utilized. In some examples, processor 15 may play an alarm tone with an increasing volume until readings from biometric sensor(s) 19 indicate that the user has awoken. After providing an alarm tone and confirming that the user has awoken, processor 15 may return to step 3 in order to provide another sleep signal when the user should once again attempt to sleep. If processor 15 determines that the sleep latency assessment has concluded, then processor 15 may forgo the alarm tone and conclude the sleep latency assessment routine.

[52] At step 7, if processor 15 determines that sufficient latency assessment cycles have been conducted, processor 15 may then prepare a report regarding the user's sleep latency, while allowing a user to continue sleeping (box 507). A sleep latency report may include summary statistics regarding a user's overall ability to fall asleep or may provide all of the data stored in the sleep record through the course of the sleep latency assessment. The sleep latency report may be transmitted through communications hardware 17 to a third party, such as a healthcare professional. This latency assessment data may be received by another device, where it can be stored in memory or another storage device, or can be displayed to a user. In other examples, a user's sleep latency assessment report may be maintained on sleep assessment device 1, but permission for third parties (e.g. a doctor or healthcare professional) to access the information via a network may be granted by a user. Such information may be useful for a healthcare professional to diagnose a potential sleep disorder or continue to monitor a user's progress during treatment for an already-diagnosed sleep disorder.

[53] One of skill in the art will appreciate that the systems, methods and apparatuses outlined above may include various hardware and operating software, familiar to those of skill in the art,

for running software programs as well as communicating with and operating any devices, including, for example, a biometric sensor, environmental sensors, a user interface, a computer network, a sound system, and any other internal or external devices. Such computerized systems may also include memory and storage media, and other internal and external components which may be used for carrying out the operations of this disclosure. Moreover, such computer systems may include one or more processors for processing and controlling the operation of the computer system, thus, embodying the processes of this disclosure. To that end, the processor, associated hardware and communications systems may carry out the various examples presented herein.

[54] While the disclosed subject matter is described herein in terms of certain exemplary implementations, those skilled in the art will recognize that various modifications and improvements can be made to the disclosed subject matter without departing from the scope thereof. As such, the particular features claimed below and disclosed above can be combined with each other in other manners within the scope of the disclosed subject matter such that the disclosed subject matter should be recognized as also specifically directed to other implementations having any other possible permutations and combinations. It will be apparent to those skilled in the art that various modifications and variations can be made in the systems and methods of the disclosed subject matter without departing from the spirit or scope of the disclosed subject matter. Thus, it is intended that the disclosed subject matter include modifications and variations that are within the scope of the appended claims and their equivalents.

What is claimed is:

CLAIMS

1. A sleep assessment device comprising:
at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user;
a processor; and
memory;
wherein said processor is configured to detect a user's sleep state by reading signals from said at least one biometric sensor;
wherein said processor is further configured to log information in a sleep record, including biometric information detected during the period a user is sleeping; and
wherein said processor is configured to compare said logged information in said sleep record to a thumbprint of sleep patterns and output an indication of potential sleep disorders based on said comparison.
2. The sleep assessment device of claim 1, further comprising a microphone.
3. The sleep assessment device of claim 1, wherein the thumbprint is a thumbprint of a normal sleep pattern.
4. The sleep assessment device of claim 1, wherein the thumbprint is a thumbprint of a known sleep disorder.
5. The sleep assessment device of claim 4, wherein the sleep disorder is one of: sleep apnea, sleep talking, sleep walking, and snoring.
6. The sleep assessment device of claim 1, wherein the processor is further configured to output a notification of a potential sleep disorder.

7. The sleep assessment device of claim 6, further comprising a transmitter for transmitting the notification of a potential sleep disorder.

8. The sleep assessment device of claim 1, further comprising at least one direct biometric sensor, wherein said processor is configured to detect a user's sleep state by reading signals from said at least one direct biometric sensor.

9. The sleep assessment device of claim 8, wherein said at least one direct biometric sensor is a blood oxygen sensor.

10. The sleep assessment device of claim 2, wherein said processor is further configured to detect sound while a user is sleeping and log sound information into said sleep record.

11. A method for providing an indication of a potential sleep disorder comprising: providing at least one contactless biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user;

detecting a user's sleep state by reading signals from said at least one contactless biometric sensor;

logging information in a sleep record, including biometric information relating to the quality of a user's sleep;

comparing said logged information in said sleep record to a thumbprint of sleep patterns; determining whether a potential sleep disorder exists based on said comparison; and providing an indication that a potential sleep disorder exists.

12. The method claim 11, further comprising providing at least one direct biometric sensor and reading signals from said at least one direct biometric sensor.

13. The method of claim 13, wherein said at least one direct biometric sensor is a blood oxygen sensor.

14. The method claim 11, further comprising:
providing at least one microphone;
reading signals from said at least one microphone; and
logging sound information in said sleep record.
15. A sleep latency assessment device comprising:
at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a user;
a processor; and
memory;
wherein said processor is configured to detect a user's sleep state by reading signals from said at least one biometric sensor;
wherein said processor is further configured to provide a sleep signal and record the amount of time after the sleep signal is provided before said biometric sensor indicates that said user has fallen asleep.
16. The sleep latency assessment device of claim 15, wherein said processor is further configured to provide an alarm signal a predetermined amount of time after a user has fallen asleep.
17. The sleep latency assessment device of claim 16, wherein said processor is further configured to provide at least a second sleep signal after a user has awoken and record the amount of time after said at least a second sleep signal is provided before said biometric sensor indicates that said user has fallen asleep at least a second time.
18. The sleep latency assessment device of claim 17, wherein said processor is further configured to determine whether additional sleep latency assessment cycles are required based on predetermined sleep latency assessment criteria.

19. The sleep latency assessment device of claim 18, wherein said processor is further configured to generate a sleep latency assessment report based on at least one sleep latency assessment cycle.

20. A method for assisting a user sleep comprising:
providing a sleep assistance device comprising at least one speaker, at least one microphone, a processor, and at least one biometric sensor for detecting at least one of a heart rate, respiration, or movement of a first user;
determining that a first user has fallen asleep based on signals received from said biometric sensor;
detecting sounds emanating from said first user through said microphone;
determining a noise-masking sound based on said detected sounds emanating from said first user; and
playing said noise-masking sound through said at least one speaker for assisting a second user sleep.

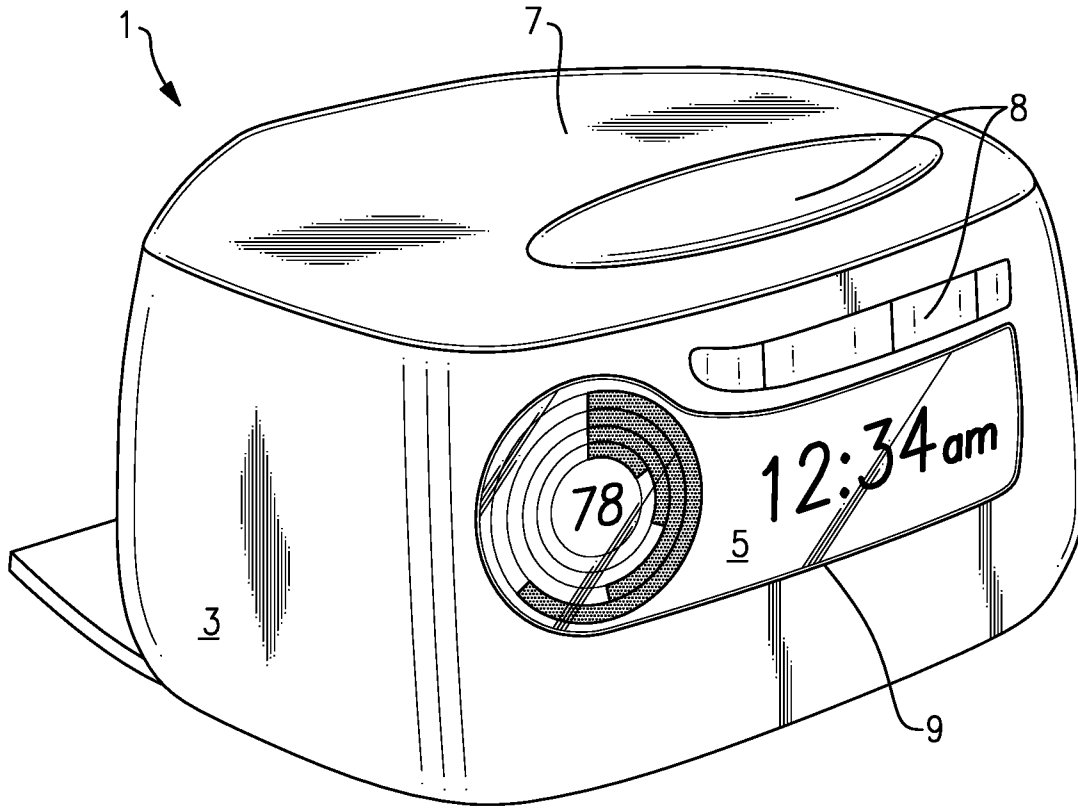


FIG. 1A

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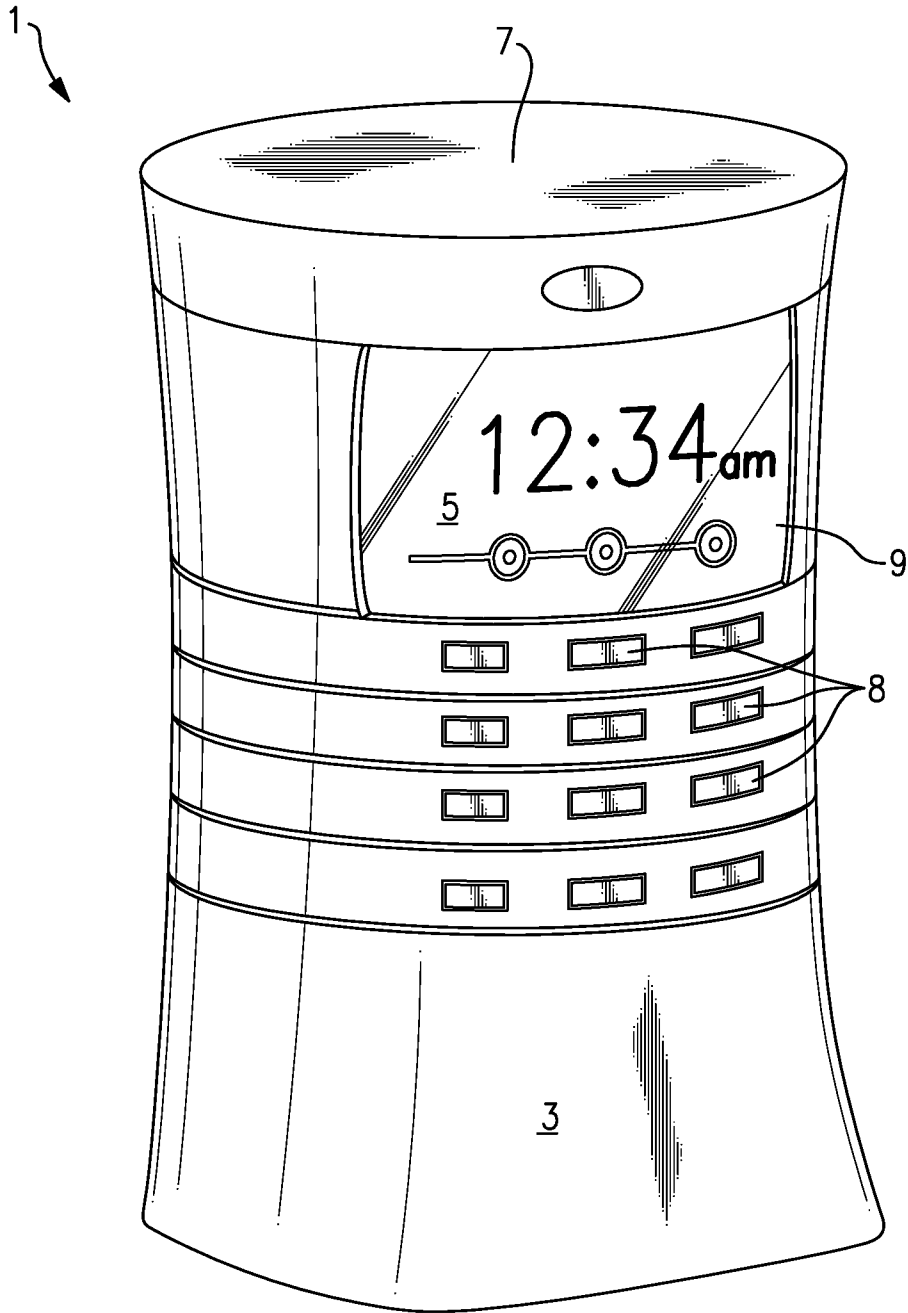


FIG.1B

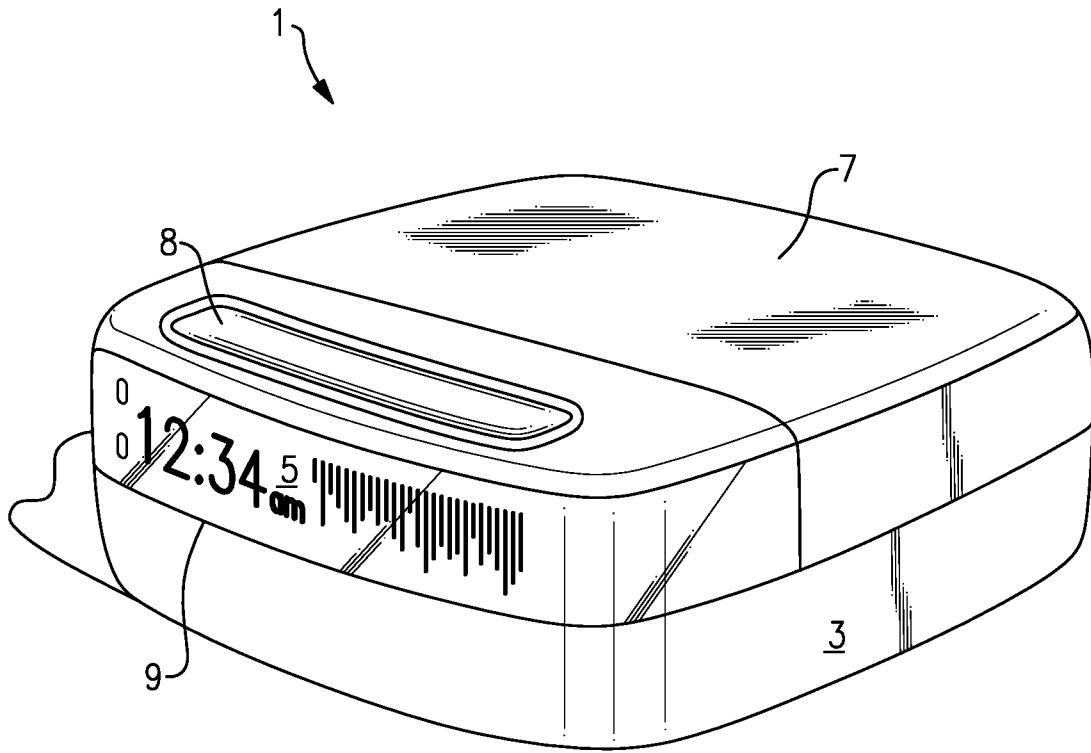


FIG. 1C

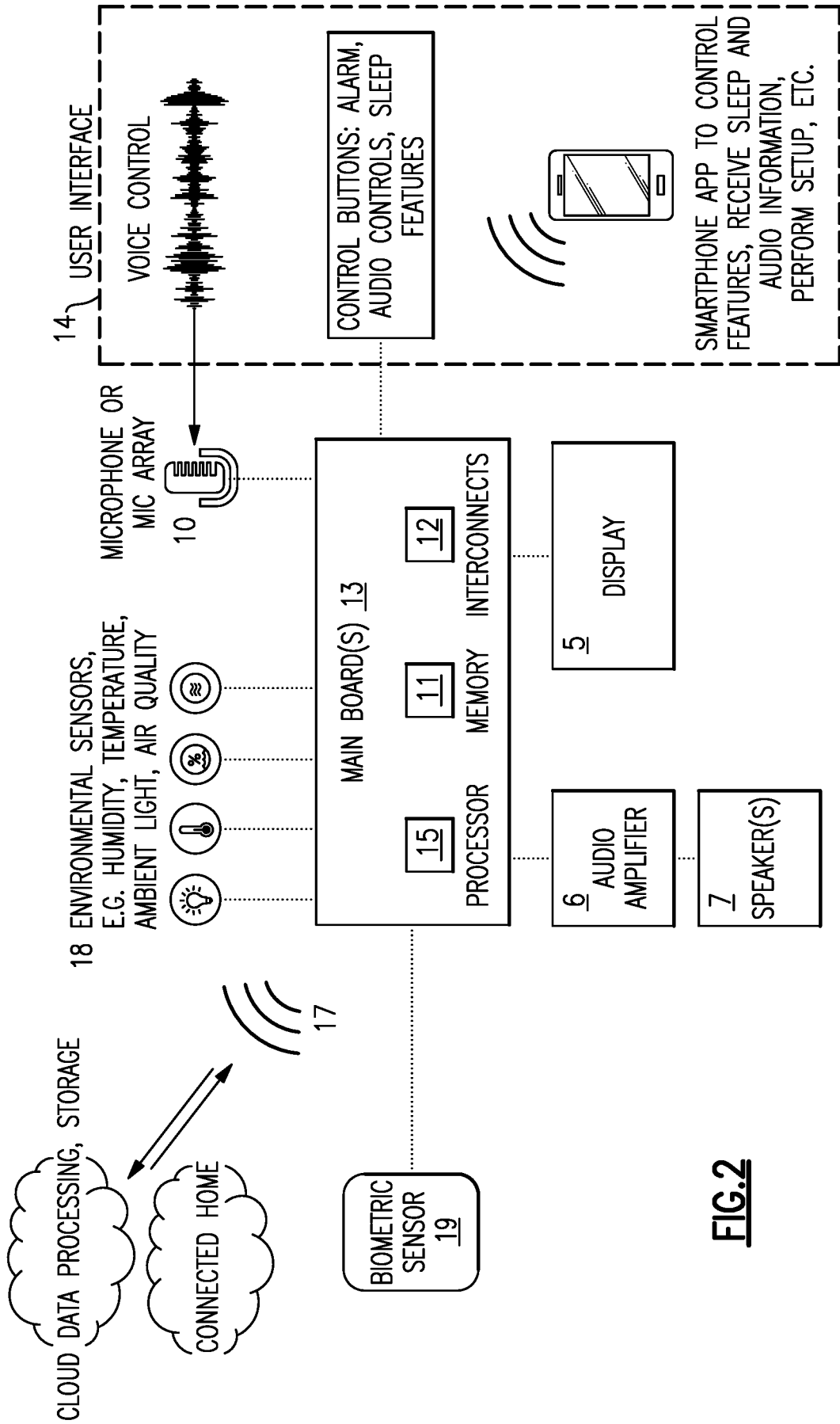


FIG. 2

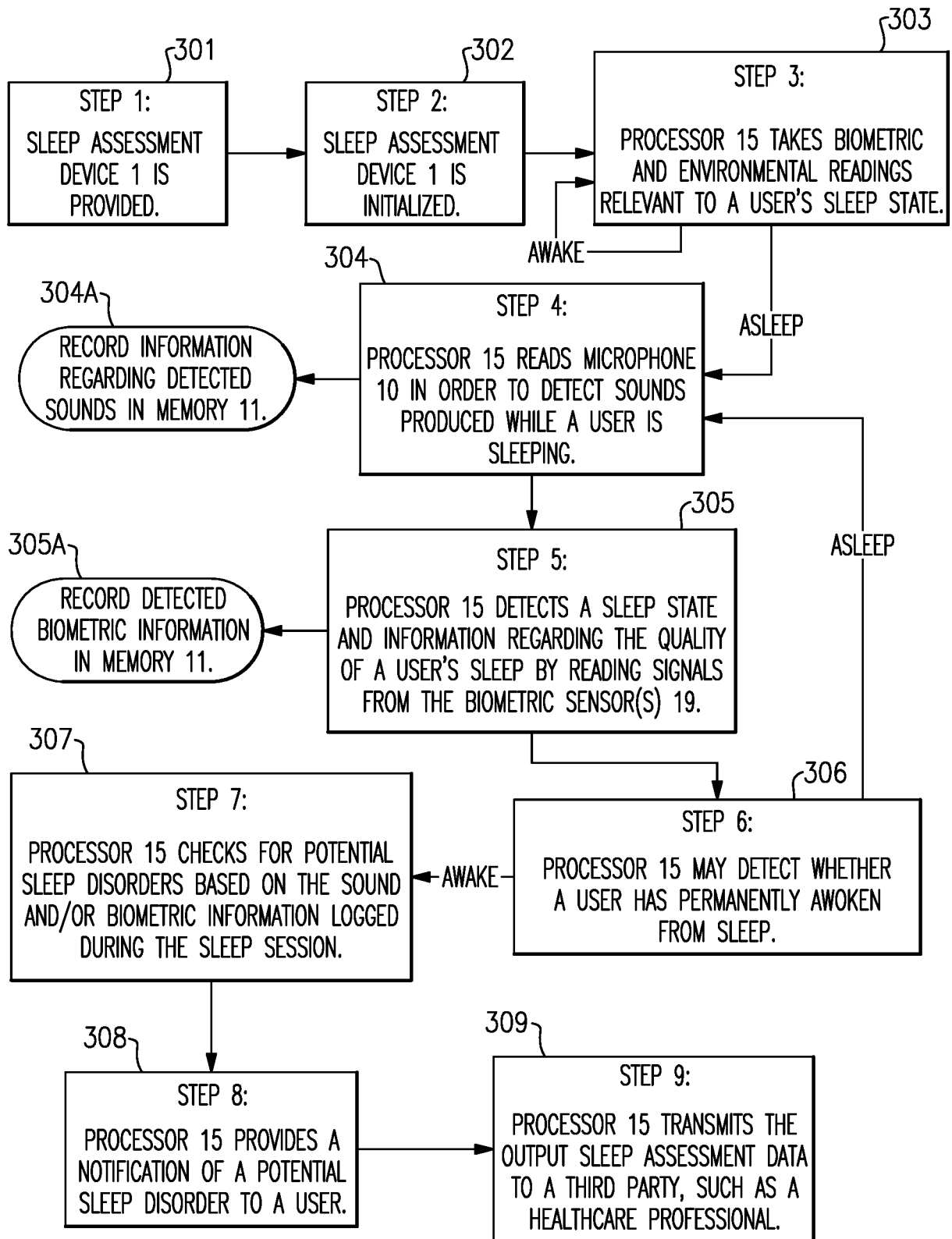


FIG.3

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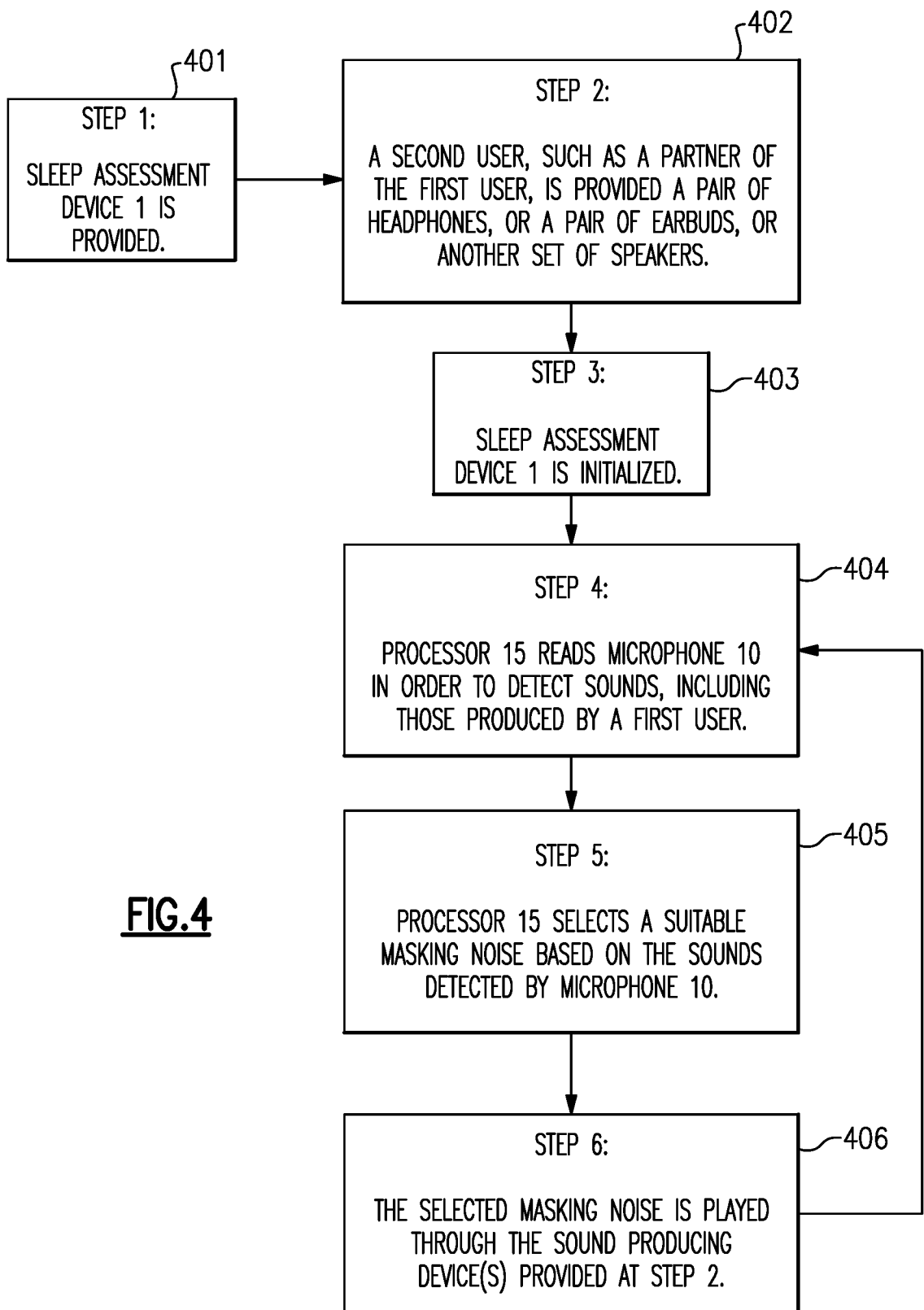


FIG.4

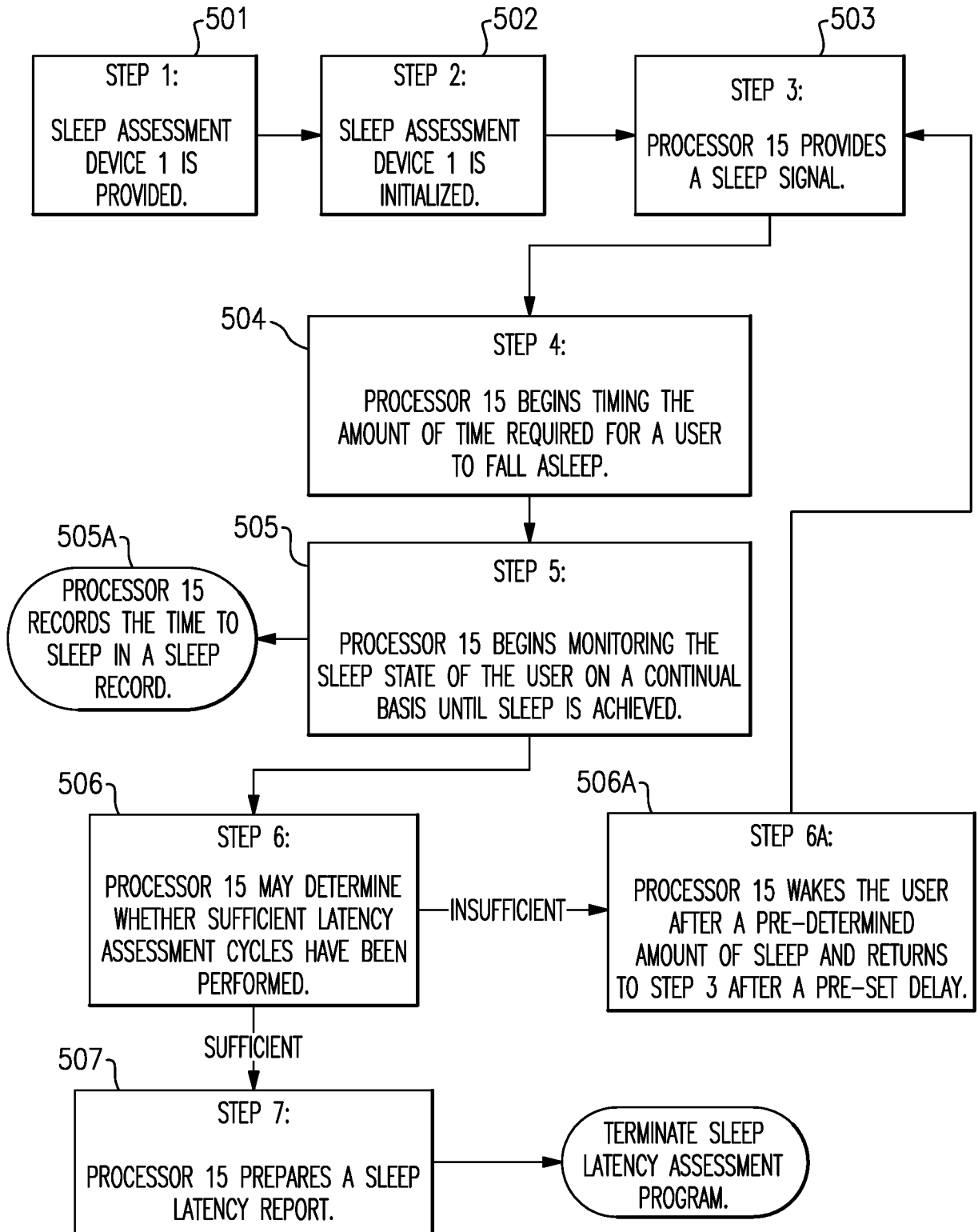


FIG.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/051617

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61M21/02
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)
A61B A61M

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 2012/051630 A2 (QUALCOMM INC [US]; HWANG KYUWOONG [US]; LEE TE-WON [US]; YOU KISUN [US]) 19 April 2012 (2012-04-19)	1-7, 10, 11, 14
Y	paragraphs [0004] - [0006], [0021] - [0026], [0033], [0036], [0045]	8, 9, 12, 13
Y	WO 2016/142793 A1 (QUATTRONE ALDO [IT]; GAMBARDELLA ANTONIO [IT]; SALSONE MARIA [IT]; VES) 15 September 2016 (2016-09-15) page 4, line 29 - page 6, line 34 page 12, lines 4-30	8, 9, 12, 13

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

22 November 2017

Date of mailing of the international search report

01/12/2017

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/051617

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/084538 A1 (AXON SLEEP RES LAB INC [US]; ROTHMAN DANIEL [US]; RUBIN BENJAMIN S [US]) 15 September 2005 (2005-09-15) page 2, lines 27-31 page 4, line 19 - page 6, line 17 page 7, line 25 - page 12, line 2 page 14, lines 7-18 page 16, lines 1-10 -----	15-19
X	WO 2015/061579 A1 (QUANTTUS INC [US]) 30 April 2015 (2015-04-30) page 59, line 12 - page 60, line 10 page 100, line 23 - page 102, line 24 -----	15-19
X	US 2008/157956 A1 (RADIVOJEVIC ZORAN [FI] ET AL) 3 July 2008 (2008-07-03) paragraphs [0024] - [0027], [0042], [0043], [0069], [0070] -----	20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/051617

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

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

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
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:

see additional sheet

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20

sleep state assessment

1.1. claims: 1-14

detecting potential sleep disorder

1.2. claims: 15-19

determining sleep latency

1.3. claim: 20

detecting noise during sleep and outputting noise masking sound to another user

专利名称(译)	使用家庭睡眠系统进行睡眠评估		
公开(公告)号	EP3512411A1	公开(公告)日	2019-07-24
申请号	EP2017777126	申请日	2017-09-14
[标]申请(专利权)人(译)	伯斯有限公司		
申请(专利权)人(译)	Bose公司		
当前申请(专利权)人(译)	Bose公司		
[标]发明人	REICH DEBRA WARE LAURA FREED JONATHAN READ JACK KESHAVAN LEELA MULCAHEY BRIAN DAVID		
发明人	REICH, DEBRA WARE, LAURA FREED, JONATHAN READ, JACK KESHAVAN, LEELA MULCAHEY, BRIAN, DAVID		
IPC分类号	A61B5/00 A61M21/02		
CPC分类号	A61B5/0022 A61B5/0205 A61B5/0255 A61B5/0803 A61B5/1123 A61B5/14542 A61B5/4806 A61B5/4812 A61B5/4815 A61B5/4818 A61B5/4836 A61B5/6898 A61B5/746 A61B7/003 A61B2560/0462 A61B2562/0204 A61M21/02 A61M2021/0027 A61M2205/3303 A61M2205/3306 A61M2205/3368 A61M2205/3553 A61M2205/52 A61M2230/06 A61M2230/42 A61M2230/63 G16H40/67 A61M2230/005 A61B5/4803 A61B2560/0475		
优先权	15/267886 2016-09-16 US		
外部链接	Espacenet		

摘要(译)

提供了一种睡眠评估装置，包括用于检测用户的心率，呼吸或运动的生物传感器。该设备通过读取来自生物识别传感器的信号来检测用户的睡眠状态，并将检测到的信息记录在睡眠记录中。然后，该设备将记录的信息与指示睡眠障碍的睡眠模式的指纹进行比较，并基于该比较输出潜在的睡眠障碍的指示。