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(54) **SYSTEMS AND METHODS FOR PROVIDING A WAKING MECHANISM**

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A61B 5/04	(2006.01)

(52) **U.S. Cl.**

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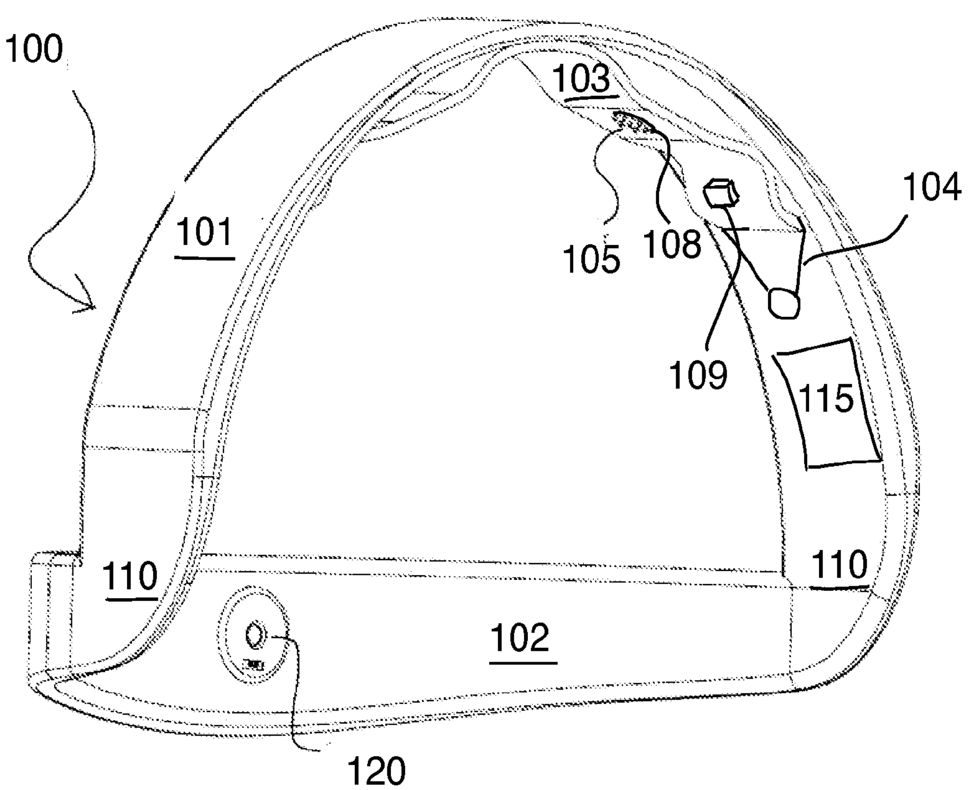
(57) **ABSTRACT**

An EEG monitor with sensors placed to detect signals and analyze the signals to determine if a frequency below 12 Hz, and more particularly between 3 Hz and 8 Hz, called theta waves, are present. Theta waves are generated when the brain is entering a drowsy or sleep mode. The sensors detect brain wave signals and transmit the signals to a microprocessor which analyzes the signals and determines the brain waves being detected. The brain waves are continuously monitored and the data is continuously transmitted to a microprocessor. If brain waves are detected in the predetermined range of between 3 Hz and 8 Hz the microprocessor activates a stimulus, to wake up the person wearing the device. The stimulus may be visual, auditory or tactile, such as an actuator, a phone call or any other stimulus.



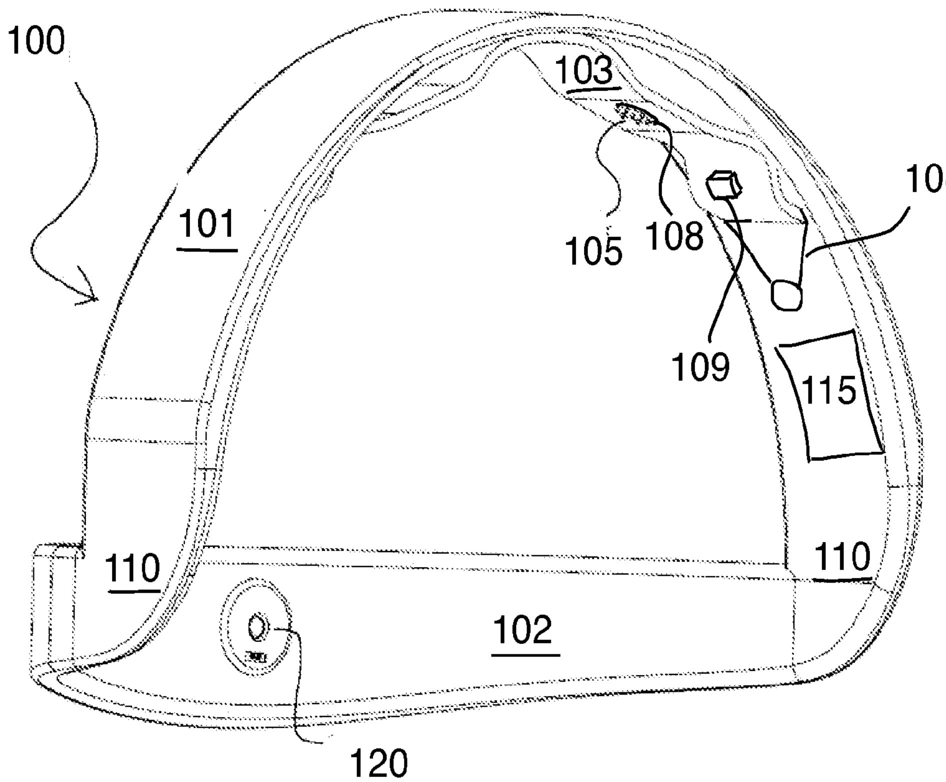


Figure 1

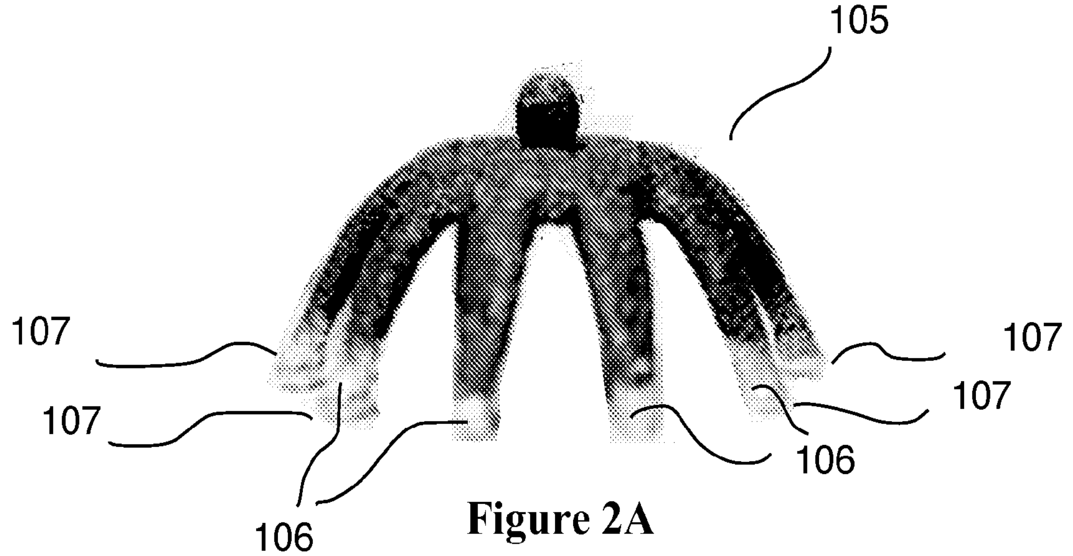


Figure 2A

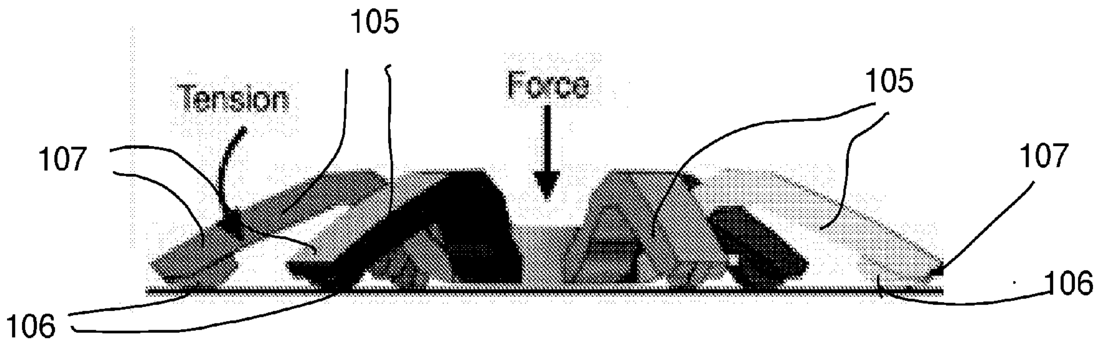


Figure 2B

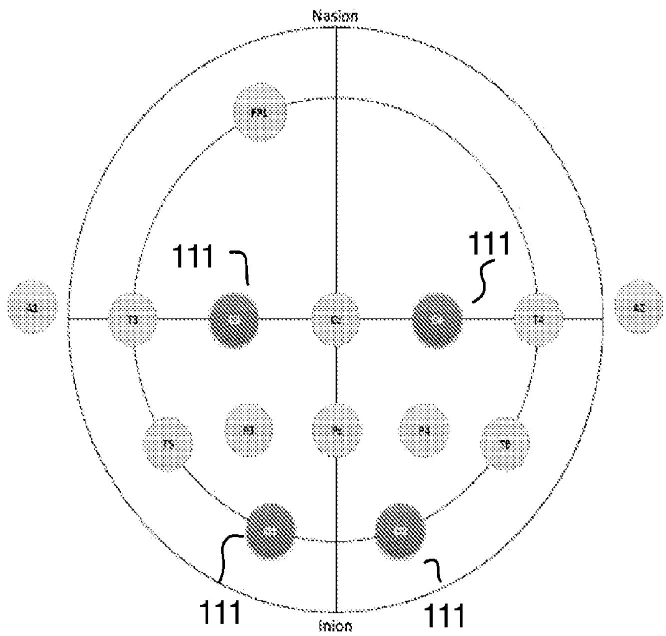


Figure 2C

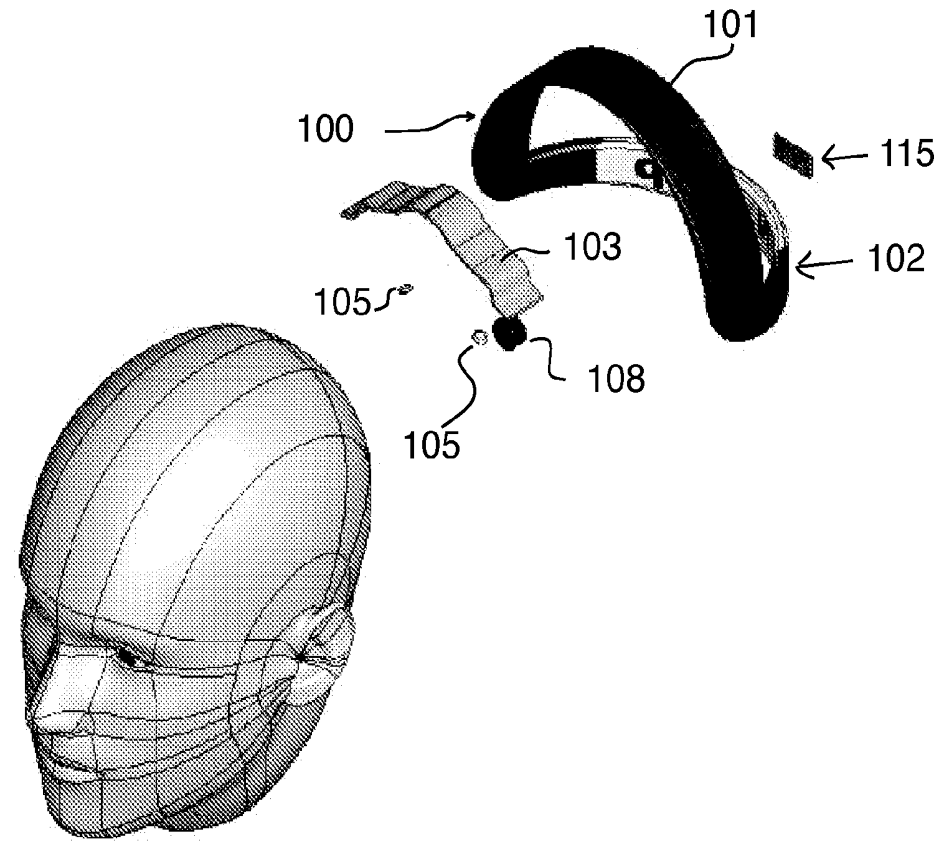


Figure 3A

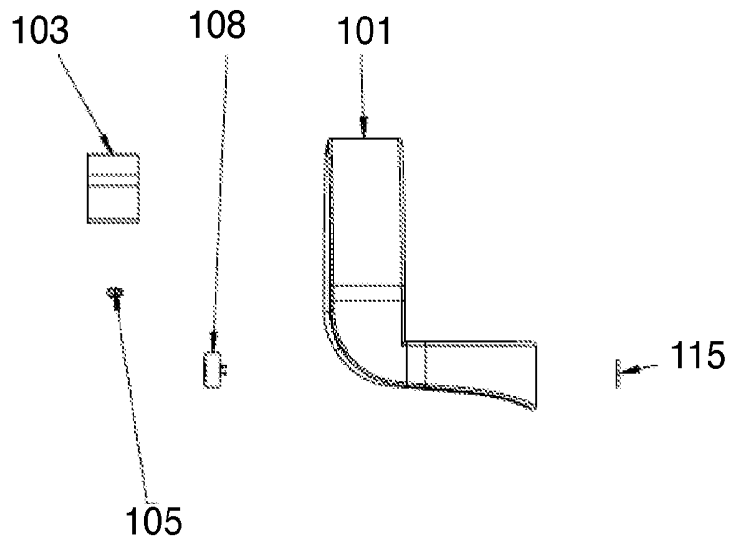


Figure 3B


405
Define lengths and filters
410
Read from the ADC, downsample and store into samples
415
for
Convolve with filter
420
Normalize
425
Take the RMS
430
Compare that value to a threshold
435
Below Threshold
440
Above Threshold
445
Activate buzzer
450
Wait for reset switch

FIG. 4A

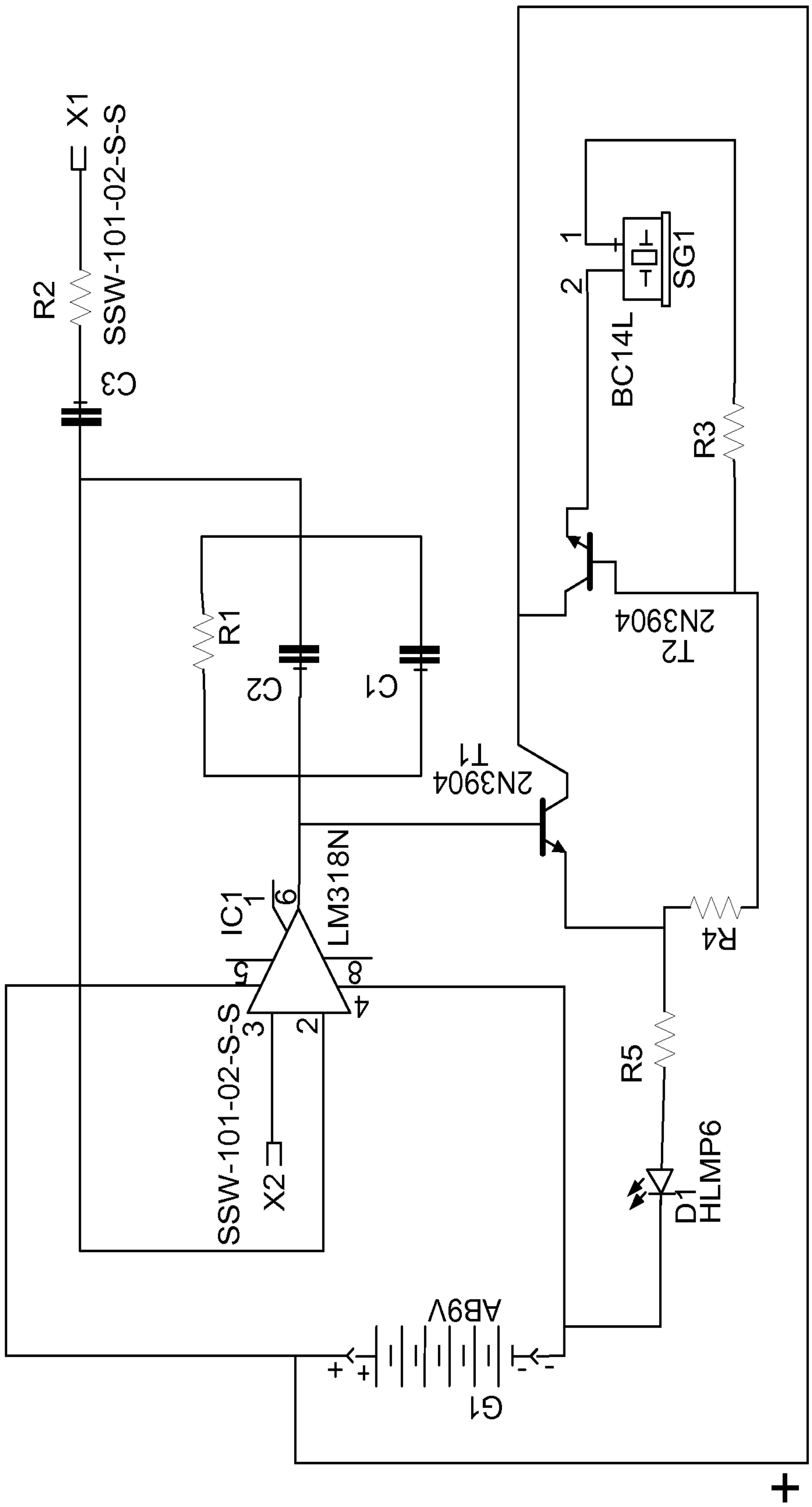

X1
SSW-101-02-S-S
R2
C3
R1
C2
C1
BC14L
SG1
R3
2N3904
T2
T1
IC1
LM318N
SSW-101-02-S-S
X2
R4
R5
D1
HLMP6
AB9V
G1
+

FIG. 4B

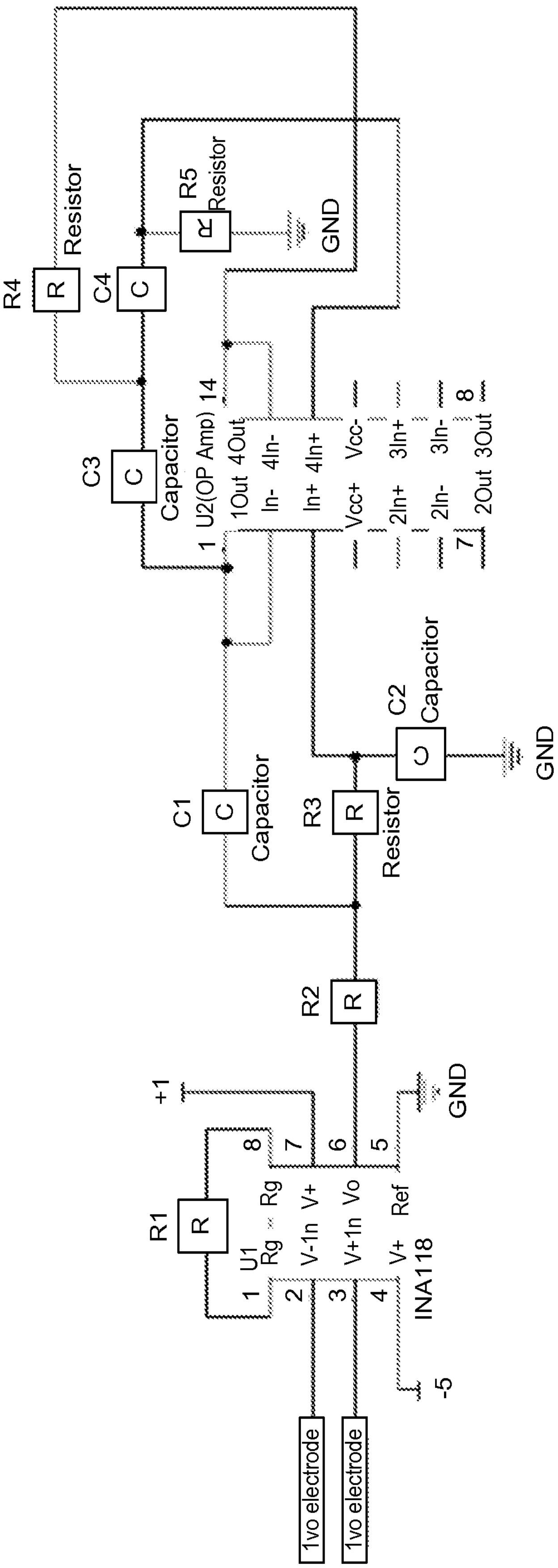

R4
Resistor
C4
R5
Resistor
GND
C3
Capacitor
U2(OP Amp)
1Out 4Out
In- 4In-
In+ 4In+
Vcc+ Vcc-
2In+ 3In+
2In- 3In-
2Out 3Out
C1
Capacitor
R3
Resistor
C2
Capacitor
GND
R2
R1
U1
INA118
Rg Rg
V-1n V+
V+1n Vo
V+ Ref
+1
GND
-5
1vo electrode
1vo electrode

FIG. 4C

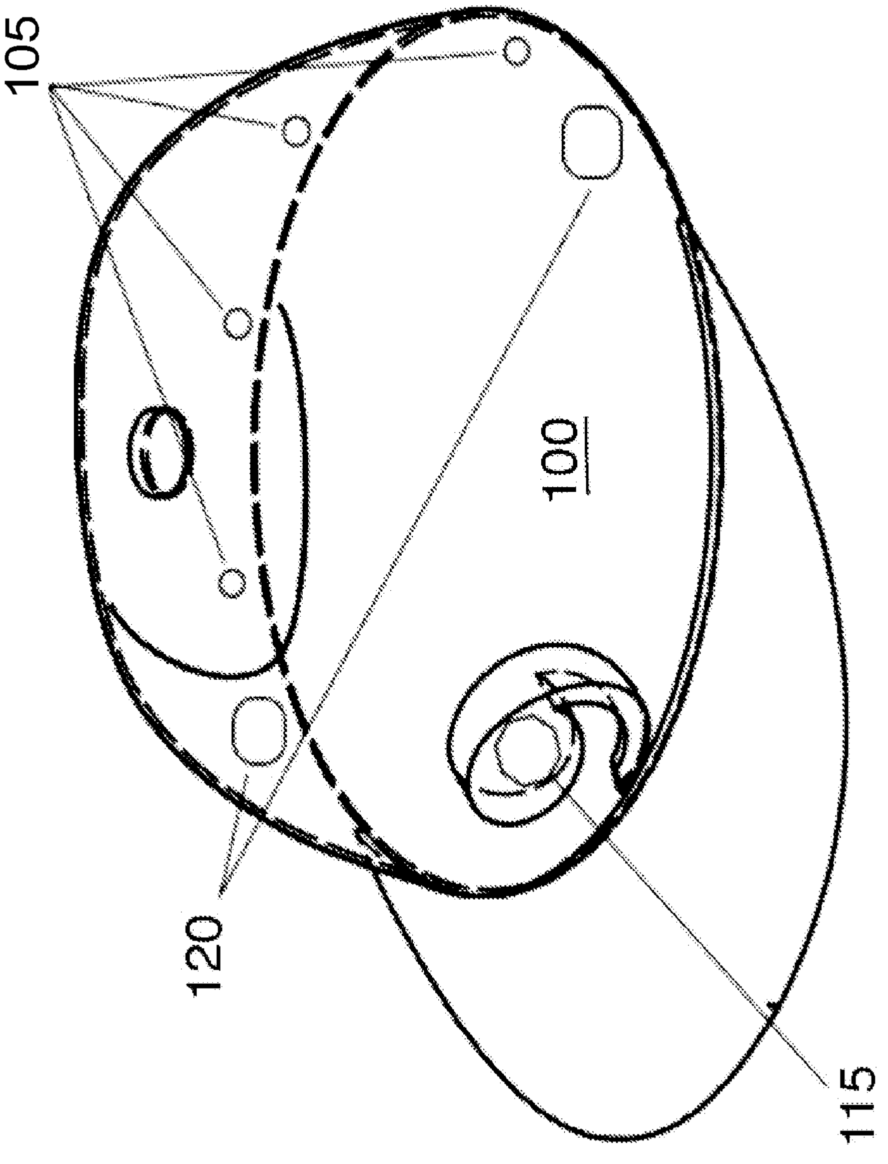


FIG. 5

SYSTEMS AND METHODS FOR PROVIDING A WAKING MECHANISM

RELATED APPLICATIONS

[0001] This Application Claims Priority to U.S. Provisional Patent Application No. 61/892,804, filed Oct. 18, 2013, entitled Dry Low-Pass Electroencephalogram Waking Mechanism.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates generally to detecting brain waves, analyzing those brain waves and applying a stimulus, or waking mechanism, when the detected brain waves are within a predetermined range, and, more particularly, to an apparatus to detect the early stages of sleep in a person applying a stimulus to wake the person up.

[0004] 2. Background of the Invention and Related Art

[0005] Research shows that the human brain emits brain waves which correspond with certain activities. Using an electroencephalogram ("EEG"), researchers have observed brain wave activity in a variety of frequencies which correspond to the brain's activity state. EEGs have been used in the medical industry for monitoring brain wave activity. For example, Beta waves comprise 16-31 Hz, Alpha waves comprise 8-15 Hz, Theta waves comprise 4-7 Hz, and Delta waves comprise 0.1-3 Hz.

[0006] EEGs have been used in the medical industry for monitoring brain wave activity but have just recently entered the consumer industry. With the invention of the EEG dry sensor, a wearable device that senses brain waves was made possible. The technology has been used in devices that integrate with software to perform various functions. However, the specific application of providing a user with a constant state of alertness has never been actualized.

[0007] Researchers generally measure beta waves and alpha waves in people who are awake and alert. Beta waves are have a high frequency and low amplitude and exhibit an inconsistent pattern and correspond with day to day activities when a person is alert and awake. Beta waves are exhibited when a person is fully awake and when higher functions such as logic and critical reasoning occur.

[0008] However, as a person relaxes, the brain begins to exhibit alpha waves, which are characterized by increased amplitude and synchronicity. These brain waves correlate with peaceful meditation.

[0009] The brain emits Theta waves as a person transitions from a wakeful state in the alpha and beta ranges to a sleep state. Theta waves further decrease in frequency and further increase in amplitude. A person who emits Theta waves as they pass from a calm relaxed state into a drowsy, but still awake state and transitions to a drowsy and fully asleep state.

[0010] Finally, Delta waves are exhibited by a person who is in a deep sleep.

[0011] The body and brain have anatomical structures which control sleep. The thalamus is brain structure responsible for consciousness. The thalamus has multiple functions. It may be thought of as a kind of switchboard of information. It is generally believed to act as a relay between different subcortical areas and the cerebral cortex. In particular, every sensory system (with the exception of the olfactory system) includes a thalamic nucleus that receives sensory signals and sends them to the associated primary cortical area. For the visual system, for example, inputs from the retina are sent to the lateral geniculate nucleus of the thalamus, which in turn projects to the visual cortex in the occipital lobe. The thalamus is believed to both process sensory information as well as relay it—each of the primary sensory relay areas receives strong feedback connections from the cerebral cortex. Similarly the medial geniculate nucleus acts as a key auditory relay between the inferior colliculus of the midbrain and the primary auditory cortex, and the ventral posterior nucleus is a key somatosensory relay, which sends touch and proprioceptive information to the primary somatosensory cortex.

[0012] The thalamus also plays an important role in regulating states of sleep and wakefulness. Thalamic nuclei have strong reciprocal connections with the cerebral cortex, forming thalamo-cortico-thalamic circuits that are believed to be involved with consciousness. The thalamus plays a major role in regulating arousal, the level of awareness, and activity. Damage to the thalamus can lead to permanent coma.

[0013] While sleep is critical to maintaining health, certain activities, such as standing guard, operating a motor vehicle or even studying cannot be properly performed while asleep or even drowsy. An estimated 20% of fatalities on the road are drowsiness related. Currently, waking mechanisms that claim to sense drowsiness do so by using motion sensors. People need something to keep them awake while driving, working, monitoring, etc.

SUMMARY

[0014] Systems and methods of monitoring brain wave activity and triggering stimuli waking mechanism based on the measured brain wave activity is disclosed. Some embodiments claim a plurality of EEG contact sensors coupled to a logic circuit. The contacts detect brain wave signals which are analyzed by the logic circuit, and when the signals are within a pre-determined range stimuli are applied. Alternatively, a method is disclosed for arousing a person who is transitioning from an alert state to a sleep state by monitoring the brain waves, and when brain waves between 3 Hz and 8 Hz are detected activating stimuli to arouse the person to a wakeful state. The device can be integrated into any style of headwear piece according to the user's style preference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In order that the manner in which the above recited and other features and advantages of the present invention are obtained, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. Understanding that the drawings depict only typical embodiments of the present invention and are not, therefore, to be considered as limiting the scope of the invention, the present invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0016] FIG. **1** illustrates an embodiment of the disclosed invention.

[0017] FIG. **2**A illustrates an embodiment of a sensor.

[0018] FIG. **2**B illustrates an alternative view of a sensor.

[0019] FIG. **2**C illustrates a map of the international 10-20 system for potential sensor placements.

[0020] FIG. **3**A illustrates an exploded view of an embodiment of the disclosed invention.

[0021] FIG. 3B illustrates parts of an embodiment of the disclosed invention.

[0022] FIG. 4A illustrates a flow diagram of an embodiment of the disclosed invention.

[0023] FIG. 4B illustrates a circuit an embodiment of the disclosed invention.

[0024] FIG. 4C illustrates a circuit an alternative embodiment of the disclosed invention.

[0025] FIG. 5 illustrates an alternative embodiment of the disclosed invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] It will be readily understood that the components of the present invention, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the system and method of the present invention is not intended to limit the scope of the invention, as claimed, but is merely representative of the presently preferred embodiments of the invention.

[0027] Referring to FIG. **1**, one embodiment of the disclosed invention comprises an EEG monitor **100** with at least sensors **105** to detect brain waves. The brain emits theta waves from the temporal lobe and alpha waves from the occipital and parietal lobes. The sensors **105** are placed to optimize reception of the signals. The desired frequency of activation is below 12 Hz, especially between 3 Hz and 8 Hz or the range of 4 Hz to 7 Hz. The detected brain wave signals are transmitted to a microprocessor which analyzes the signals and determines the brain waves being detected. These transmissions by be wired or wireless transmissions. The brain waves are continuously monitored and the data is continuously transmitted to a microprocessor for processing in intervals ranging from once every 0.01 milliseconds to once every second or longer, and preferably once every 20 milliseconds. If brain waves are detected in a predetermined range, such as below 12 Hz, or between 3 Hz and 8 Hz, then the microprocessor activates a stimulus **120**, which may be visual, auditory or tactile, such as an actuator, a phone call or any other stimulus to stimulate the brain change the waves being transmitted by it.

[0028] Referring now to FIGS. **2A-2C**, the sensor **105** may comprise any EEG sensors known in the art. The sensors may be wet or dry sensors. The sensors may be made from metal, plastic, composite or any other materials. The sensors **105** may comprise silver chloride on the tips **106** to reduce impedance and improve conductance. The sensors may comprise conductive fabrics, plastics or metals. In certain embodiments the disclosed invention inputs signals from a reference sensor and EEG sensors into an op amp, which runs the signal through a series of low-pass filters and outputs to a stimulus **120**. The power supply may comprise 6V provided by external batteries. The stimulus is customizable and can range from an audible buzzer to a vibrator motor.

[0029] The sensors **105** may be dry EEG electrodes composed of mostly silver alloy. The device may be analog and without a need to use an analog to digital converter. All sensors **105** and electronics are incorporated into a headwear piece that can be customized according the user's style.

[0030] In a preferred embodiment a dry sensor **105** manufactured by Cognionics, is used.

[0031] The sensor **105** is designed to brush through hair with modest pressure while retaining the ability to flatten for safety and comfort is used. (See FIG. **2**B). When a force is applied to the top of the sensor **105** the sensor flattens and the legs **107** of the sensor **105** are under tension, increasing the pressure between the end of the legs and the scalp. The pressure improves the contact between the sensor **105** and the scalp. Moreover, as the leg **107** is flexed the tip of the leg pushes obstructions, such as hair, out of the way to allow the sensor **105** to directly contact the scalp. The tips of the legs **107** may be coated with materials to improve the sensor's ability to detect brain waves. One coating may be silver chloride **106**. The spider-style sensor is used in connection with hair on a scalp and the tips of the "spider" legs extend through the subject's hair to directly contact the scalp.

[0032] Referring to FIGS. **1**, **3**A and **3**B, the sensors may be held in place by an EEG sensor **100**. The EEG sensor **100** apparatus may comprise a frame, or an article of clothing, such as a hat, a visor, a bandana, a skull cap, a ski hat, headband, or any other article which can position the sensors in place. In alternative embodiments the harness apparatus may comprise clips which clip the sensors to hair.

[0033] In a preferred embodiment the harness apparatus is a two-part harness with a headband portion **101** that extends across the crown of the scalp and a base portion **102** which extends around the rear base of the head. The headband portion **101** is a semi-rigid member comprising extendable sizing members to allow the length of the headband to be selectively adjusted. At least two sensors **105** are selectively coupled to the headband at least some distance apart such as **1** centimeter apart. However, in a preferred embodiment there are four sensors spaced on the headband portion **101** to be spread across the scalp so as to be optimally positioned to detect theta waves generated by the brain. In the preferred embodiment width of the headband **101** is sufficient to allow the four sensors **105** to be placed within ten percent of the C**3**, C**4** O**1** and O**2** **111** (see FIG. **2**C) locations as determined by the 10-20 electrode placement system, allowing the sensors to be optimally located to detect theta waves being emitted from the occipital and parietal lobes of the brain.

[0034] The sensors **105** may be positioned on the scalp or placed on the scalp. Placement of the sensors **105** is based on the optimal location (FIG. **2**C) necessary to detect and properly acquire the brain waves and obtain an EEG reading. The sensors may be placed according to the international 10-20 system at areas C3, C4, O1, and O**2** **111**. Each point on this system can represent between 10 and 20 percent of the total skull region. Alternative embodiments may comprise placing the sensors in alternative locations on the scalp for additional scoring channels and/or derivations. Areas A**1**, A**2**, F**7**, F**8**, Fp**1**, and Fp**2** may be used for ambient frequency references. Area Fp**1** and Fp**2** above the left and right canthi may be used for electro-oculogram recordings.

[0035] In certain embodiments a nested frame **103** nests inside the concave surface of the headband portion **101**. The frame **103** may be made of any material, and in preferred embodiments the frame **103** is compliant and made of silicone, rubber or other materials that comfortably takes the contoured shape of the person's head who is wearing the monitor **100**. The frame **103** is coupled to the headband portion by adjustable members **104**, which may comprise elastomeric members to allow the pressure applied by the compliant frame to the head is constant and adjustable. The adjustable members **104** may also comprise slide mechanisms, hook and loop system, peg and hole system, or any other mechanism or system that allows for selectively securing the nested frame **103** at the desired position.

[0036] The frame **103** may further comprise sensors **105** selectively coupled to the compliant frame. In certain embodiments foam spacers **108** may also be coupled to the frame **103**. The spacer may be doughnut-shaped **108** and surround the sensor **105** with the sensor sitting in the center of the doughnut hold. Alternatively the foam spacer may be coupled to the compliant frame some distance from the sensor to keep the applied pressure even across the subject's scalp or head. In both embodiments where the foam spacer surrounds the sensor or where the foam spacer is off-set from the senor, the foam is approximately the same height as the senor. In certain embodiments the foam is lightly less than the height of the sensor. In other embodiments the height of the foam is slightly less than the height of the senor.

[0037] The terminal ends of the headband comprise nodes **110** which couple the headband portion **101** to the base portion **102**. The node **110** is adjustable and allows the angle between the base portion **102** and the headband portion **101** to increase or decrease as needed to place properly place the sensors. The base portion **102** extends around the base of the skull. The base portion may comprise an stimulator **120**. The base portion stimulator **120** may stimulate visual, auditory or tactile senses. In a preferred embodiment the stimulator **120** vibrates and is positioned at the center base of the skull to stimulate thalamus, the brain structure responsible for sleep.

[0038] The sensors **105** are in communication with a microprocessor **115** which analyzes signals detected by the sensors **105** to determine if the detected brain waves are within the predetermined frequency range.

[0039] Referring to FIGS. **4A-4C**, an electrical circuit is created for sensing and transmitting brain signals to a microprocessor **115**. The signals from the brain are detected by sensors **105** placed on the scalp. A minimum of two sensors a minimum distance apart are needed to detect the signals. In addition, a reference value is required as well as a circuit ground. The reference provides a reference from which all other sensors are differentiated, and another sensor to provide a point from which to differentiate. The reference to ground sensor can be separated into a ground sensor and a reference sensor. The reference sensor can be of any conductive material and can be placed anywhere on the head. The reference sensor may be constantly detecting a signal, or alternatively, it may be a baseline value gathered through an initial reading and then stored in the invention's logic to obtain differentials. The reference's function is to provide a differential reference point to measure brain wave attributes. The ground sensor can be of any conductive material and can be placed anywhere on the body. Its function is an electric ground of the body. A preferred embodiment uses six sensors: one reference, one ground, and four additional sensors at C**3**, C**4**, O**1**, and O**2** **111** to pinpoint theta wave readings. The ground and reference are pad sensors, and are placed on the bare scalp. The other four sensors are spider-like flexible sensors **105** that are designed to measure through hair and still make contact with the scalp. (Both bought from Cognionics). The headband **101** apparatus ensures correct sensor placement and pressure is used. The headband apparatus **101** may include rigid and elastic parts to maintain pressure and comfort of the sensors against the head. The headband apparatus **101** can either fit inside or be integrated into existing headwear. The apparatus may be adjustable. Processing unit and additional circuitry may be housed within the apparatus.

[0040] In addition, impedance values and placement of the sensors are used to determine sensing accuracy of the invention. Thus if a sensor's impedence is high, and a signal is not being detected, then the microprocessor will generate a signal, such as the stimulator **120**, or a message, such as a text message to an off-site location to notify the system is gathering data and the subject's wakefulness state. The invention will determine when sensing accuracy is within a desired range and notify the user. Notification may occur with audible, optical, or other methods. The invention may also notify the user if sensing accuracy is not within desired range using any of the same methods.

[0041] The signals are detected by sensors **105** and go through a filtering circuit which may include various amplifying circuitry, anti-aliasing filters, analog digital converters, a microprocessor, power supply, and waking mechanism. The signal noise may be reduced or eliminated by any of the aforementioned devices. The microcontroller processes the signal as follows: Algorithm defines time and size of data packets **405**. The signals are read from the analog digital converter **410**, down-sampled based on means **410**, and stored into samples **410**. The samples go into a "for" loop which includes a convolution with filtering coefficients **415**, normalization **420**, taking the root mean square **425**, and comparing that value to a threshold **430**. Once the value exceeds the threshold, the stimulator is activated **445**. The stimulator **120** may require user input to reset to loop **450**. If threshold is not reached **435**, the "for" loop continues until it is reached. The algorithm is designed to activate once theta waves indicate microsleep or drowsiness. The algorithm may include a time-based or packet-counter based recognition function.

[0042] The stimulator **120** may include, but is not limited to an audible buzzer, a vibrating buzzer, an electric pulse, a low pulse frequency to stimulate the thalamus, a phone call, a mobile app-related action, shutting off of equipment, a magnetic pulse, or a notification via text or by push notification. Data may be recorded by a central monitoring station, if applicable.

[0043] The device may also be used to help people with sleep disorders monitor their conscious states. Applications and markets for the invention may include, but are not limited to, transportation industries, national security, police departments, manufacturing facilities, software industries, medical industries, marketing industries, call centers, educational institutions, religious institutions, consumer driving, studying, and alerting in any situation.

[0044] What is claimed:

1. An electroencephalograph monitor and stimuli apparatus comprising:
- a electroencephalography monitor further comprising a plurality of sensors in communication with a microprocessor; and
- a stimulus that is activated when the microprocessor detects a signal in a pre-determined range.

2. The apparatus of claim **1** wherein the sensors further comprise dry-contact sensors.

3. The apparatus of claim **1** wherein the logic circuit further comprises a digital circuit, the digital circuit further comprising a timer.

4. The apparatus of claim **1** further comprising head gear wherein the sensors integrated into headgear wherein the sensors are positioned so as to optimally detect theta waves.

5. The apparatus of claim **1** further comprising a communication link wherein the communication link transmits signals based on the waves being analyzed.

6. The stimuli of claim **1** further comprising an actuator, coupled to the head gear and positioned to stimulate a thalamus.

7. The apparatus of claim **1** wherein the stimuli further comprises auditory stimuli, visual stimuli or tactile stimuli.

8. A method of monitoring brain waves and activating a stimulus comprising;
- detecting brain waves;
- analyzing the brain waves;
- determining if the measured brain waves are below a threshold and;
- activating a stimulus based on measuring a frequency below the threshold.

9. The method of claim **8** wherein:
- the method for analyzing the frequency of brain waves further comprises:
  - detecting brain wave signals and defining the signals in a time and size of data packets;
  - reading the signals from an analog digital converter;
  - down-sampling the signals based on means
  - storing into samples in a microprocessor;
  - passing the samples through a "for" loop which further comprises a convolution with filtering coefficients,
- normalizing the samples;
- taking the root mean square of the samples, and
- comparing the root mean square value to a predetermined threshold value.

10. The method of claim **9** further comprising activating a stimulus if the root mean square value exceeds the predetermined threshold value.

11. The method of claim **10** further comprising requiring user input to reset to loop.

12. The method of claim **9** further comprising continuing the "for" loop until the predetermined threshold is reached.

13. The method of claim **9** further wherein the method further comprises reducing the noise signal by filtering the signal by methods consisting of amplifying circuitry, anti-aliasing filters, analog digital converters, a microprocessor, power supply, and waking mechanism.

14. The method of claim **8** wherein the threshold is below 12 Hz.

15. The method of claim **8** wherein the threshold is between 3 Hz and 8 Hz.

16. The method of claim **8** wherein the threshold is in the range of 4 Hz to 7 Hz.

17. A brain wave monitoring system for detecting theta waves comprising:
- an EEG monitor comprising a headband portion and a base portion wherein the headband portion further comprises four EEG sensors, a ground lead and an actuator stimulator;
- wherein the sensors are dry sensors selectively coupled to a compliant frame nested within the concave surface of the headband portion and spaced so as to be positioned approximately at the optimal placement for detecting theta waves being emitted from a subject's occipital and parietal lobes; and **[text missing or illegible when filed]**

18. The monitor of claim **17** wherein the circuit further comprises a digital circuit.

19. The monitor of claim **17** wherein the circuit further comprises a timer which measures the duration a sensor has measured voltage fluctuations in the pre-identified range

20. The monitor of claim **17** wherein the further comprises a communication link wherein a message can be sent to a central dispatch.

* * * * *

patsnap

专利名称(译)	提供唤醒机制的系统和方法
公开(公告)号	US20150282731A1
公开(公告)日	2015-10-08
申请号	US14/518343
申请日	2014-10-20
[标]申请(专利权)人(译)	NODSTOP
申请(专利权)人(译)	NODSTOP，LLC
当前申请(专利权)人(译)	NODSTOP，LLC
[标]发明人	HILL NATHANEAL MILLER JONATHAN ADAMS LOREN KRATZER LOGAN TEANCUM
发明人	HILL, NATHANEAL MILLER, JONATHAN ADAMS, LOREN KRATZER, LOGAN TEANCUM
IPC分类号	A61B5/0482 A61B5/18 A61B5/00 A61B5/04
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其他公开文献	US10441190
外部链接	Espacenet USPTO

摘要(译)

一种带有传感器的EEG监视器，用于检测信号并分析信号，以确定是否存在低于12Hz，特别是3Hz和8Hz之间的频率，称为θ波。当大脑进入困倦或睡眠模式时会产生Theta波。传感器检测脑电波信号并将信号传输到微处理器，微处理器分析信号并确定被检测的脑电波。连续监测脑电波并将数据连续传输到微处理器。如果在3Hz和8Hz之间的预定范围内检测到脑电波，则微处理器激活刺激，以唤醒佩戴该设备的人。刺激可以是视觉的，听觉的或触觉的，例如致动器，电话呼叫或任何其他刺激。