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REPUBLICATION

(54) **SYSTEM AND DEVICE FOR SEIZURE DETECTION**

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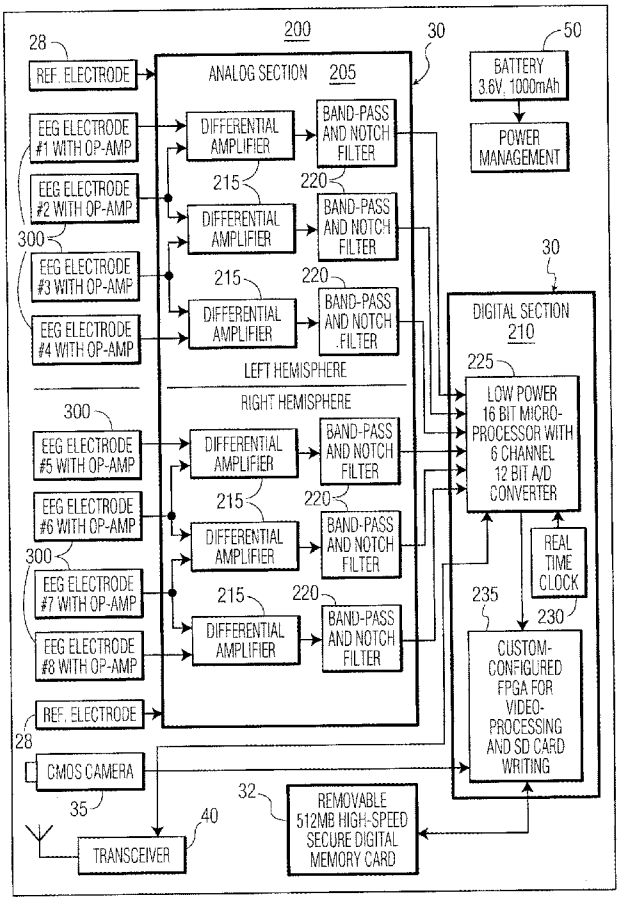
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(57) **ABSTRACT**

A device comprises a head mounting arrangement sized and shaped to be worn on a user's head and a plurality of electrodes disposed on the arrangement so that, when the arrangement is worn on the user's head, the electrodes contact target portions of a scalp to detect electrical activity of a brain of the user in combination with an image capture device disposed on the arrangement so that, when the arrangement is worn on the user's head, a field of view of the image capture device includes a portion of an anatomy of the user and a processing unit generating EEG data from the electrical activity, wherein, when the EEG data is indicative of an epileptic event, the processing unit activates the image capture device to capture video data of the user and may store the EEG and/or the video data with transmission of warning signals to one or more remote displaying and/or computing arrangements.



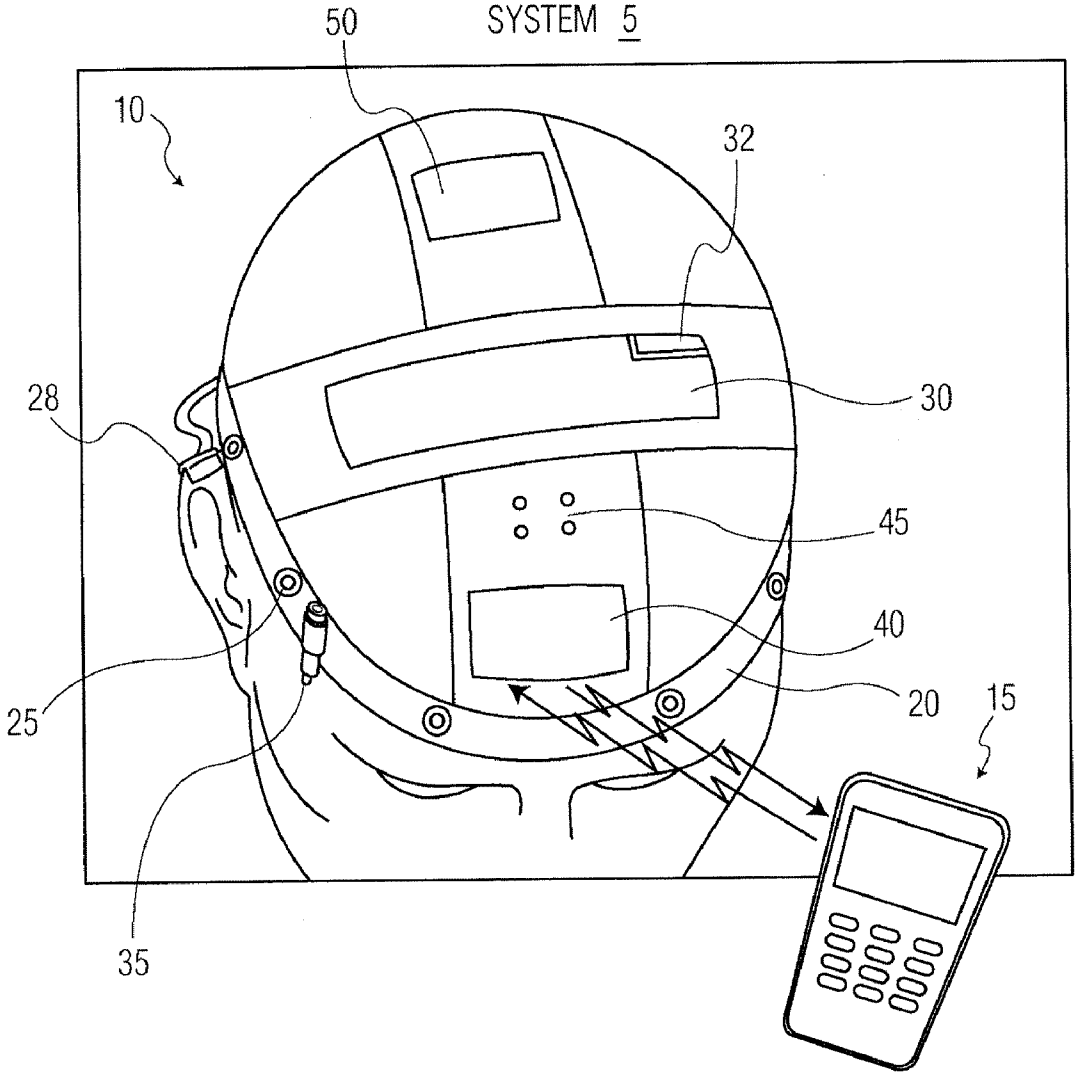


FIG. 1

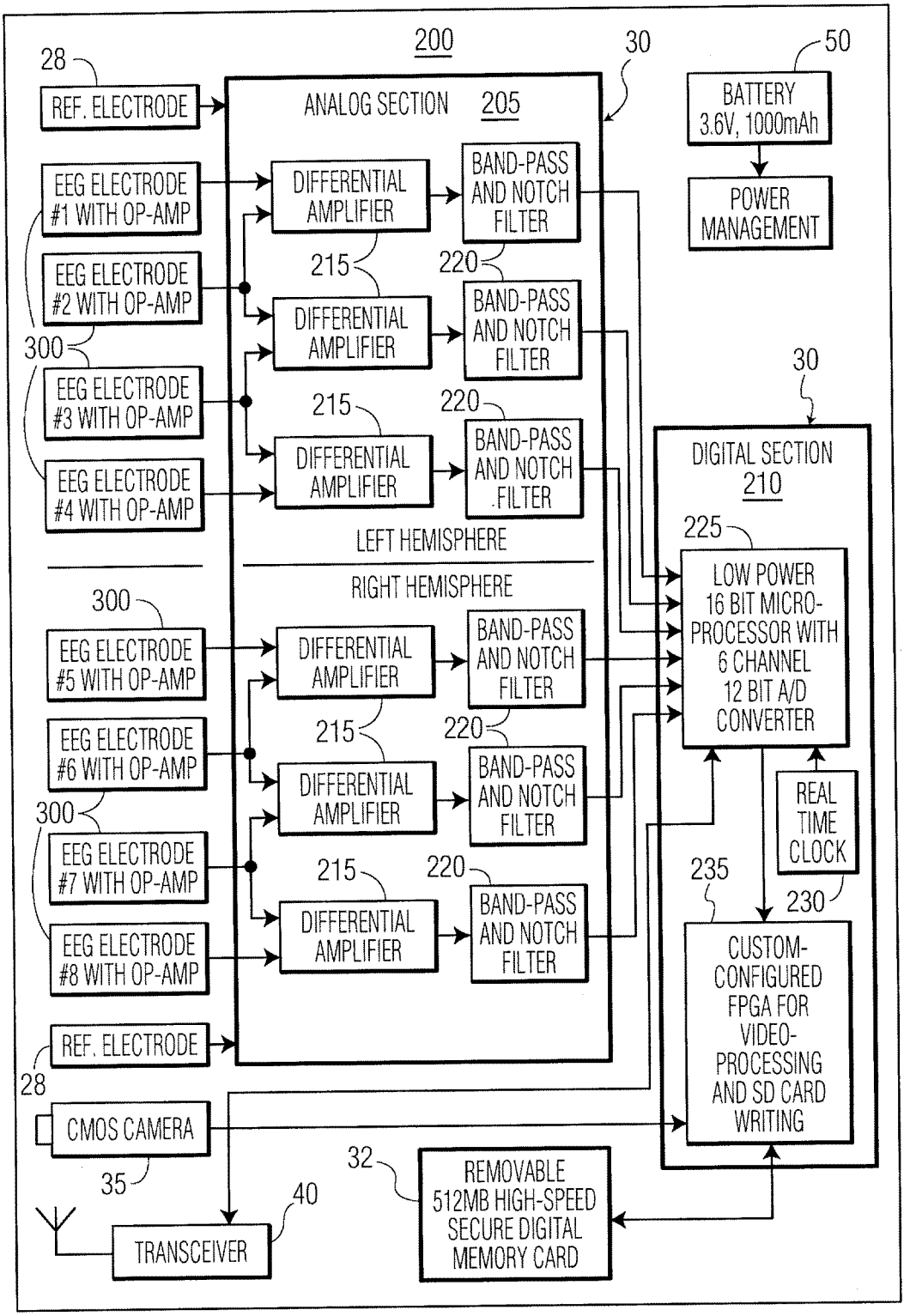

200
30
50
28
REF. ELECTRODE
ANALOG SECTION 205
BATTERY 3.6V, 1000mAh
POWER MANAGEMENT
EEG ELECTRODE #1 WITH OP-AMP
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
215
220
EEG ELECTRODE #2 WITH OP-AMP
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
300
30
EEG ELECTRODE #3 WITH OP-AMP
215
220
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
DIGITAL SECTION 210
EEG ELECTRODE #4 WITH OP-AMP
LEFT HEMISPHERE
225
RIGHT HEMISPHERE
300
LOW POWER 16 BIT MICRO-PROCESSOR WITH 6 CHANNEL 12 BIT A/D CONVERTER
EEG ELECTRODE #5 WITH OP-AMP
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
215
220
EEG ELECTRODE #6 WITH OP-AMP
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
REAL TIME CLOCK
300
235
230
EEG ELECTRODE #7 WITH OP-AMP
215
220
DIFFERENTIAL AMPLIFIER
BAND-PASS AND NOTCH FILTER
CUSTOM-CONFIGURED FPGA FOR VIDEO-PROCESSING AND SD CARD WRITING
EEG ELECTRODE #8 WITH OP-AMP
REF. ELECTRODE
28
CMOS CAMERA
35
32
REMOVABLE 512MB HIGH-SPEED SECURE DIGITAL MEMORY CARD
40
TRANSCEIVER

FIG. 2

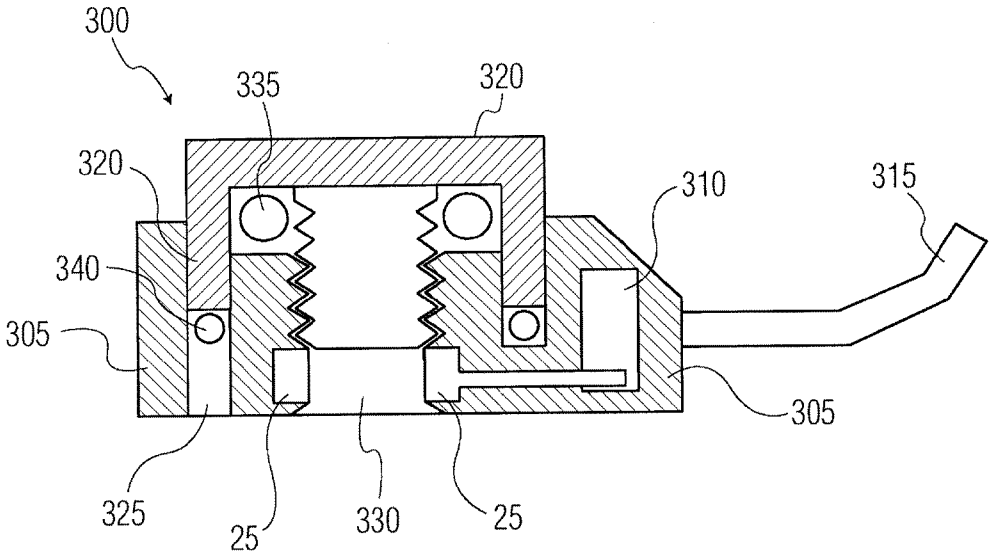

300
335
320
320
310
315
340
305
305
325
25
330
25

FIG. 3A

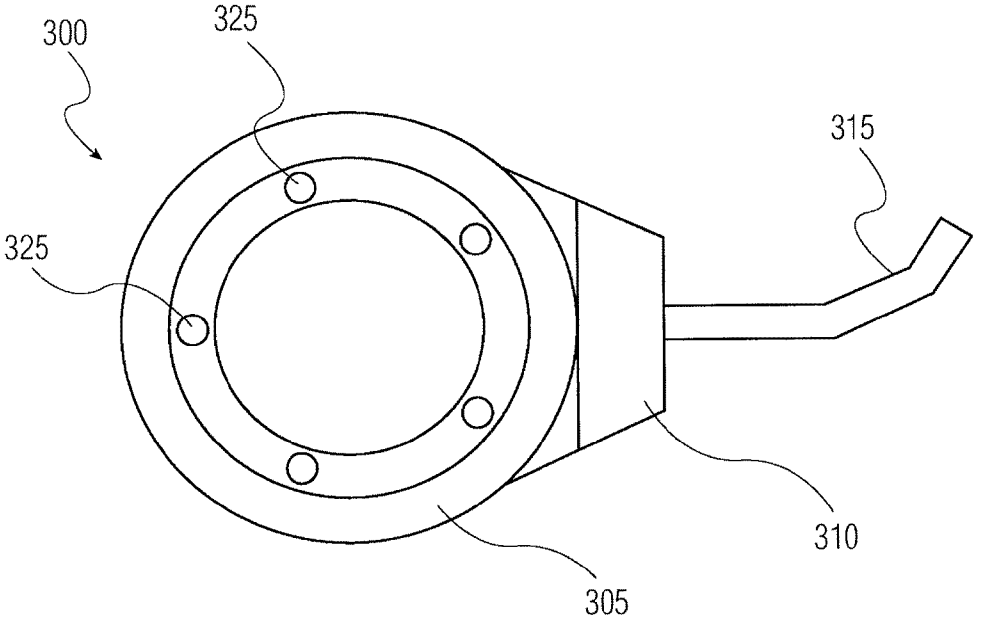

300
325
315
325
310
305

FIG. 3B

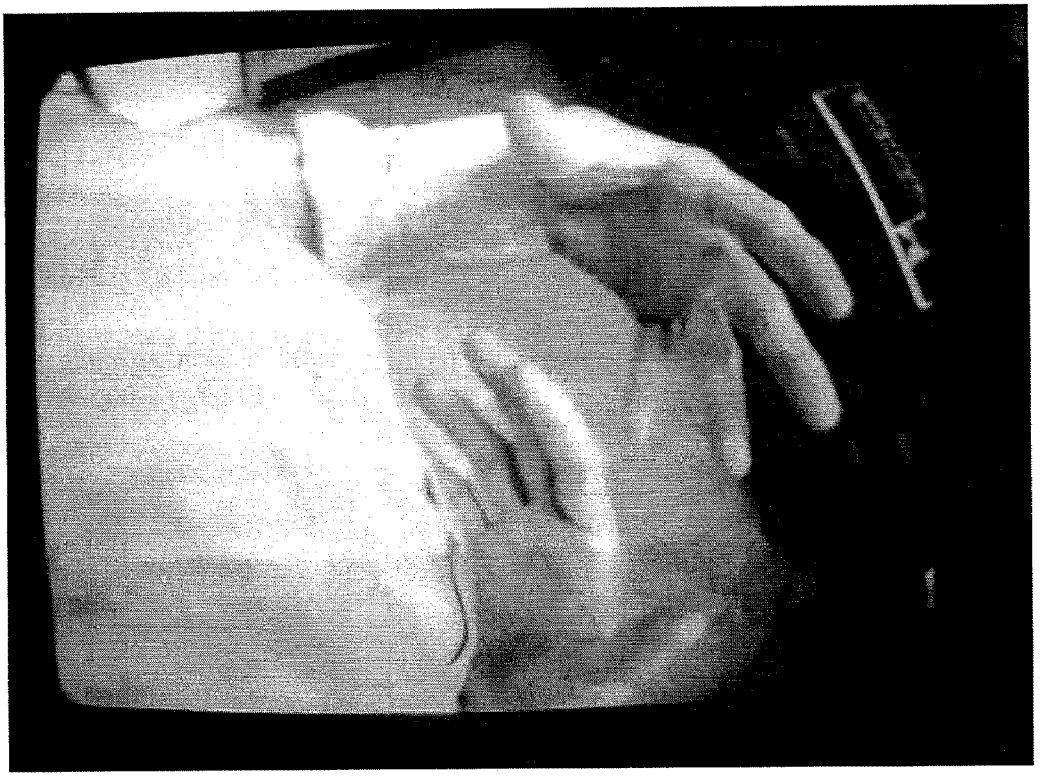


FIG. 4

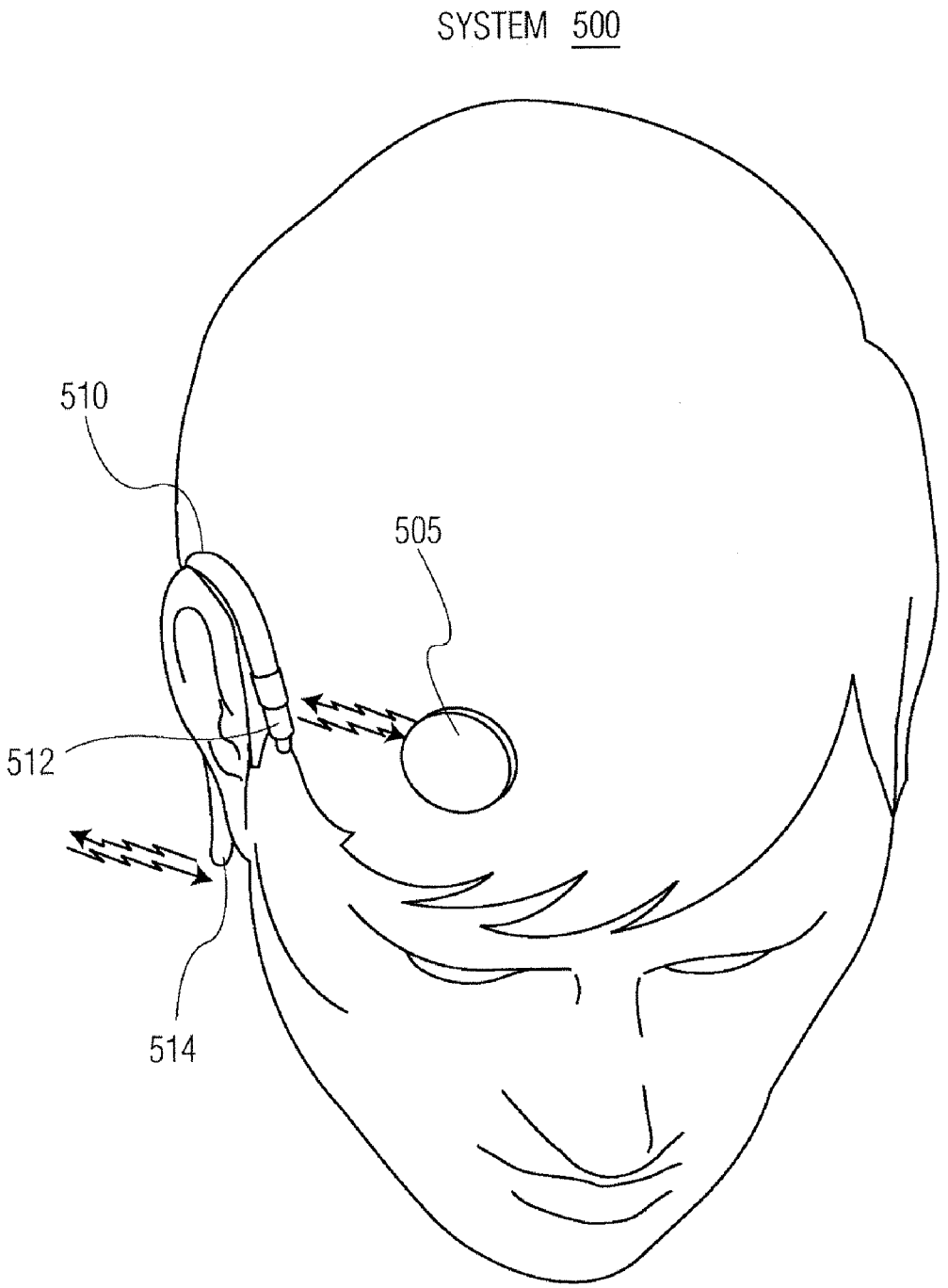


FIG. 5

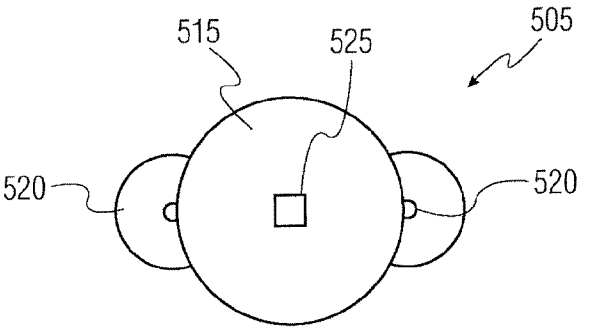


FIG. 6a

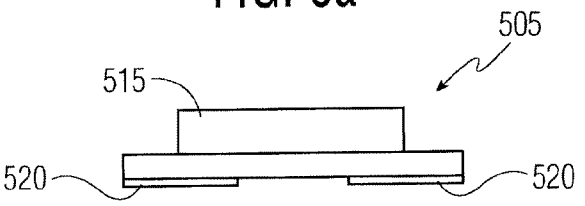


FIG. 6b

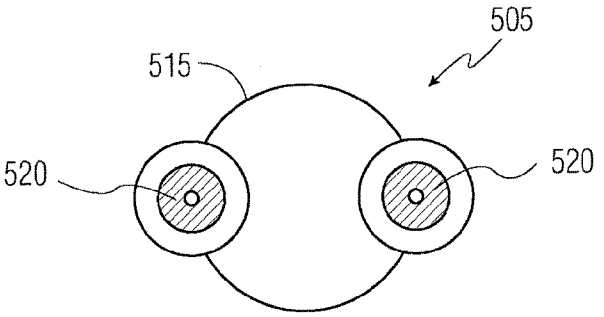


FIG. 6c

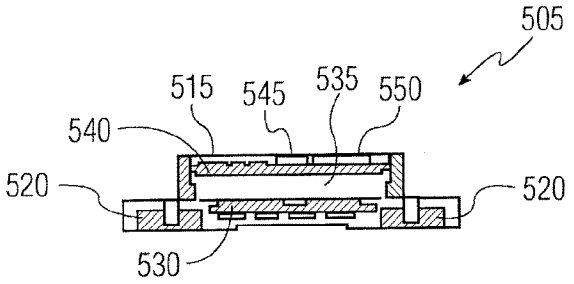


FIG. 6d

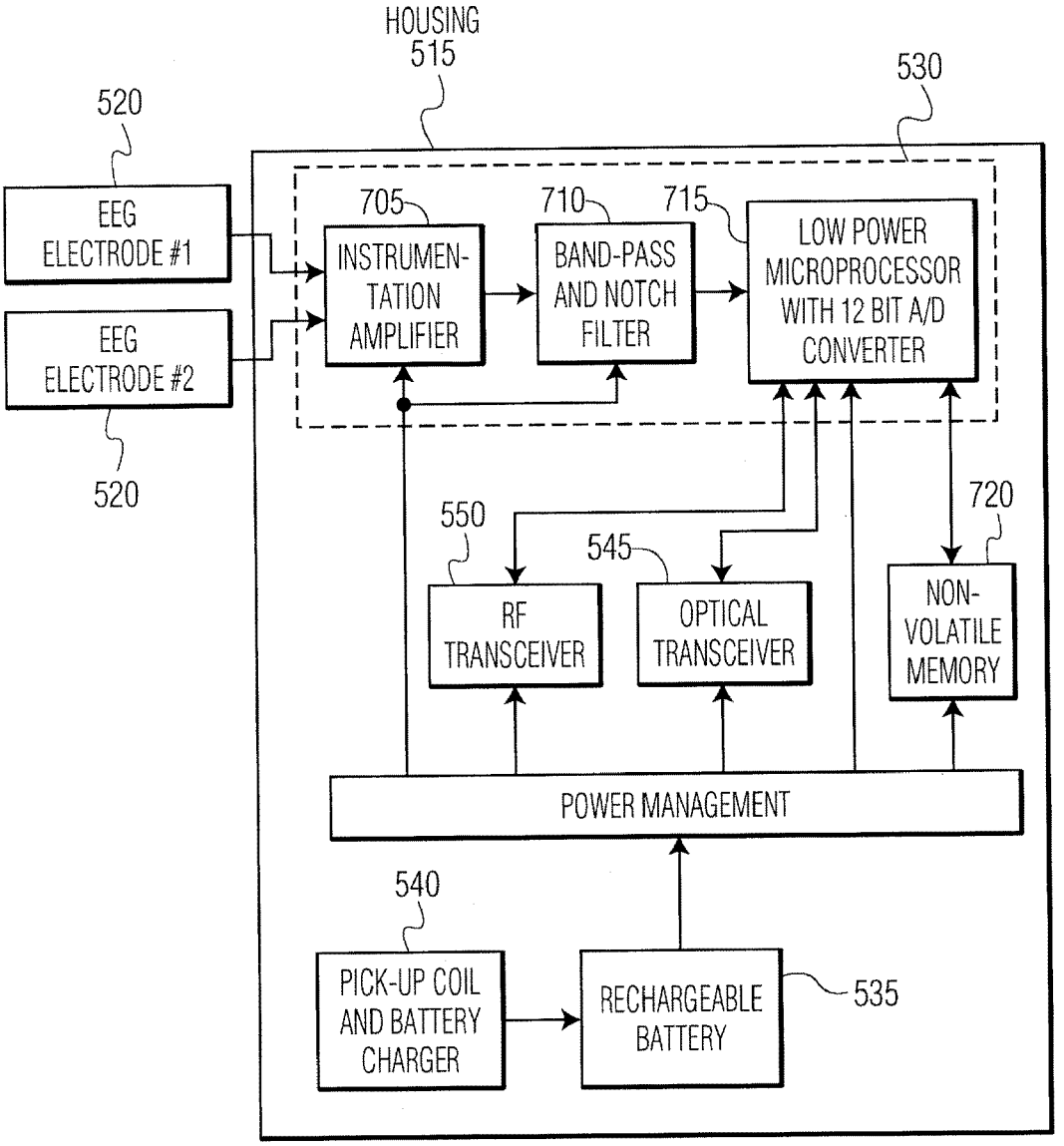

HOUSING
515
530
520
EEG
ELECTRODE #1
EEG
ELECTRODE #2
520
705
INSTRUMEN-
TATION
AMPLIFIER
710
BAND-PASS
AND NOTCH
FILTER
715
LOW POWER
MICROPROCESSOR
WITH 12 BIT A/D
CONVERTER
550
RF
TRANSCEIVER
545
OPTICAL
TRANSCEIVER
720
NON-
VOLATILE
MEMORY
POWER MANAGEMENT
540
PICK-UP COIL
AND BATTERY
CHARGER
RECHARGEABLE
BATTERY
535

FIG. 7

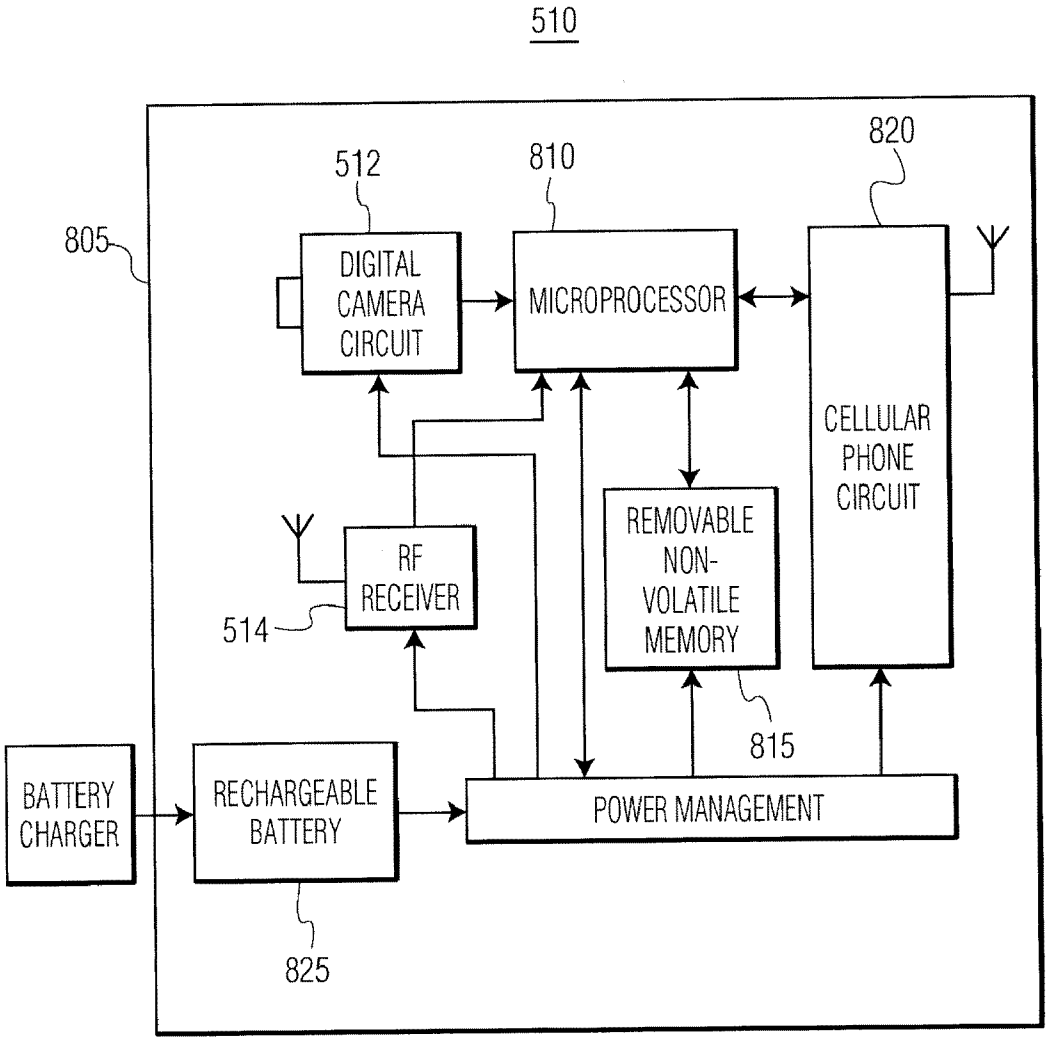

510
512
810
820
805
DIGITAL CAMERA CIRCUIT
MICROPROCESSOR
CELLULAR PHONE CIRCUIT
REMOVABLE NON-VOLATILE MEMORY
RF RECEIVER
514
815
BATTERY CHARGER
RECHARGEABLE BATTERY
POWER MANAGEMENT
825

FIG. 8

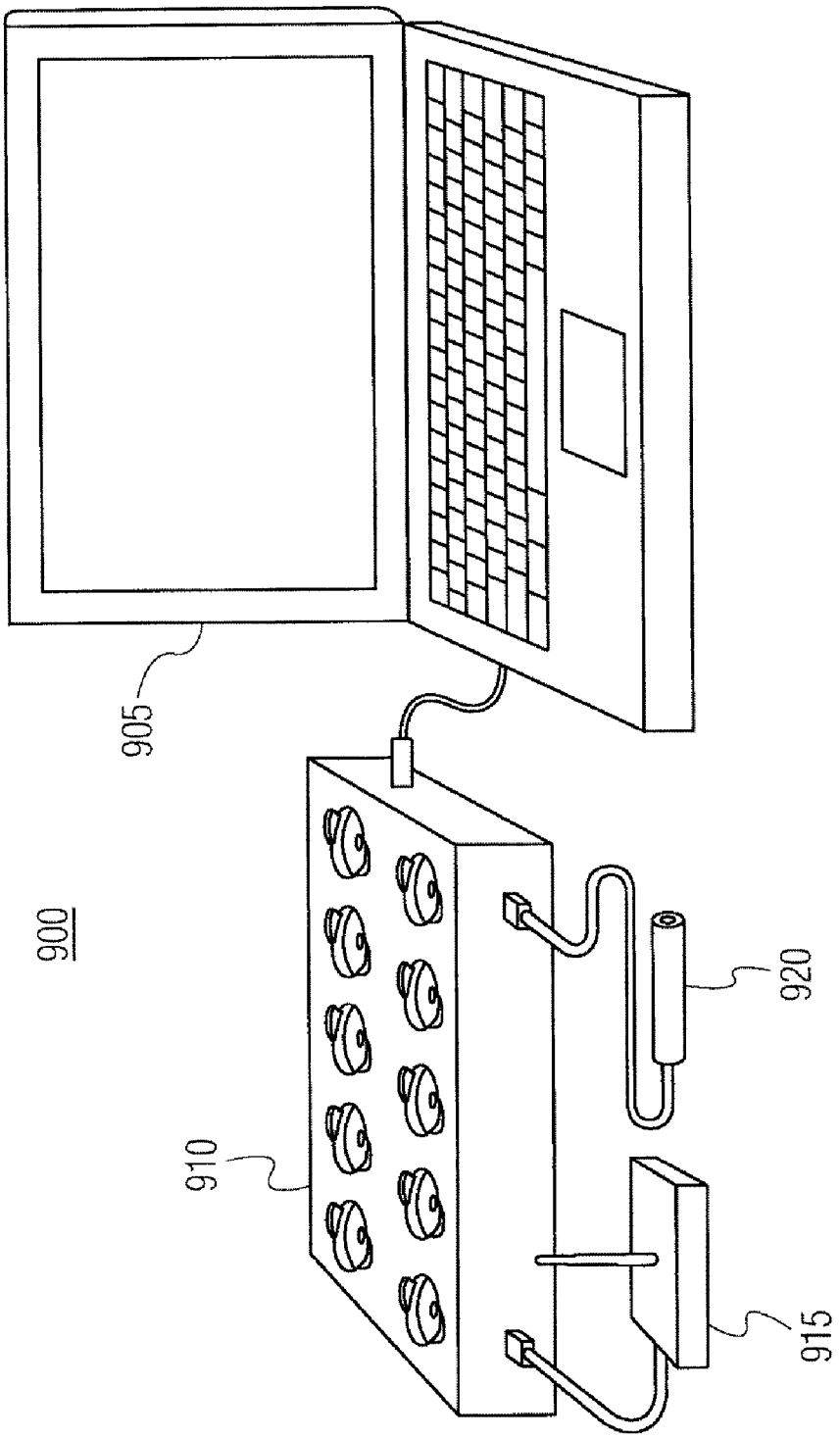


FIG. 9

SYSTEM AND DEVICE FOR SEIZURE DETECTION

BACKGROUND

[0001] Ambulatory epilepsy diagnosis and monitoring systems have been developed to capture epileptic events in non-clinical settings and alleviate the costs associated with long-term, in-patient monitoring sessions conducted in hospitals. The ambulatory system consists of a data acquisition arrangement that captures brain waves of a subject and a video camera mounted on a tripod for capturing video of the subject. The physician may then review the brain waves and the video offline to analyze the subject's activity and any epileptic events that may have occurred during a monitoring period.

[0002] The conventional data acquisition arrangement tends to be bulky and heavy, limiting the subject's range of movement and inhibiting performance of daily tasks. That is, the subject may not be able to cook, clean, do laundry or relax comfortably while tethered to the data acquisition arrangement. Additionally, the video camera is statically positioned and captures only a limited viewing range. If the subject is outside of the viewing range or if the video camera is otherwise non-functional (out of tape, battery dead, etc.), the subject's activity and the epileptic event(s) will not be captured. Thus, the conventional ambulatory systems severely restrict the subject's activity and movement even in non-clinical settings.

SUMMARY OF THE INVENTION

[0003] The present invention relates to a seizure detector headset comprising a head mounting arrangement sized and shaped to be worn on a user's head and a plurality of electrodes disposed on the arrangement so that, when the arrangement is worn on the user's head, the electrodes contact target portions of a scalp to detect electrical activity of a brain of the user in combination with an image capture device disposed on the arrangement so that, when the arrangement is worn on the user's head, a field of view of the image capture device includes a portion of an anatomy of the user and a processing unit generating EEG data from the electrical activity, wherein, when the EEG data is indicative of an epileptic event, the processing unit activates the image capture device to capture video data of the user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** shows an exemplary embodiment of a wearable EEG system according to the present invention.

[0005] FIG. **2** shows an exemplary embodiment of an architecture of a wearable EEG arrangement according to the present invention.

[0006] FIG. **3***a* shows a cross-sectional view of an exemplary embodiment of an EEG electrode unit according to the present invention.

[0007] FIG. **3***b* shows an underside view of an exemplary embodiment of an EEG electrode unit according to the present invention.

[0008] FIG. **4** shows an exemplary embodiment of video data captured by a wearable EEG arrangement according to the present invention.

[0009] FIG. **5** shows an alternative exemplary embodiment of a wearable EEG system according to the present invention.

[0010] FIG. **6***a* shows a top view of an exemplary embodiment of an EEG minidisc according to the present invention.

[0011] FIG. **6***b* shows a side view of an exemplary embodiment of an EEG minidisc according to the present invention.

[0012] FIG. **6***c* shows a bottom view of an exemplary embodiment of an EEG minidisc according to the present invention.

[0013] FIG. **6***d* shows a cross-sectional view of an exemplary embodiment of an EEG minidisc according to the present invention.

[0014] FIG. **7** shows an exemplary embodiment of an architecture of an EEG minidisc according to the present invention.

[0015] FIG. **8** shows an exemplary embodiment of an architecture of a video camera unit according to the present invention.

[0016] FIG. **9** shows an exemplary embodiment of a charger/data reader system according to the present invention.

DETAILED DESCRIPTION

[0017] The present invention may be farther understood with reference to the following description and the appended drawings, wherein like elements are provided with the same reference numerals. The present invention relates to a system and device for seizure detection. The exemplary embodiments of the present invention provide a seizure detector headset which comprises a wearable electroencephalogram (EEG) system that monitors and processes EEG signals of a subject to detect an epileptic event, provide visual evidence of the epileptic event and alert caregivers and/or medical/emergency personnel that the epileptic event is occurring. Additionally, the EEG signals produced before, during and after the epileptic event may be recorded and analyzed to diagnose (or revise a diagnosis of) the subject and/or prescribe a treatment protocol. The "epileptic event" as used herein refers to any brain activity indicative of a seizure or seizure-related symptom, any brain activity indicative of the onset of a seizure and/or any brain activity indicating that a seizure is likely to occur in the near future (i.e., within a predetermined time period). The predetermined time period is preferably measured in minutes.

[0018] FIG. **1** shows an exemplary embodiment of a wearable EEG system **5** according to the present invention. The system **5** may be embodied as a seizure detector headset which comprises a wearable EEG arrangement **10** communicatively linked to a computing device **15**. The wearable EEG arrangement **10** includes a headband **20** (or cap) that is sized and shaped to be mounted/worn on the head (or scalp) as shown in FIG. **1**. Preferably, the headband **20** is adjustable (e.g., mechanically, elastic, etc.) so that the wearable EEG arrangement **10** may be used on multiple subjects and allow a particular subject to rent/lease the wearable EEG system **5** for diagnostic intervals. However, those of skill in the art will understand that the headband **20** may be fitted to the particular subject when, for example, the subject is required by a physician to utilize the system **5** at all tires.

[0019] A plurality of EEG electrodes **25** may be affixed to predetermined locations on the headband **20** so that when the headband **20** is worn, the EEG electrodes **25** are disposed in

corresponding locations on the scalp. In a preferred embodiment, the headband **20** includes eight EEG electrodes **25** and two reference electrodes **28** which are attached to, for example, the ears. One exemplary electrode configuration comprises FP**1**, F**7**, C**3** and P**7** active electrodes on the left hemisphere and FP**2**, F**8**, C**4** and P**8** active electrodes on the right hemisphere. Of course, any other electrode configuration can readily be arranged. When the headband **20** is worn, the EEG electrodes **25** come in contact with the scalp to detect neurophysiological activity by measuring an intensity and pattern of electrical signals generated by the brain. Spontaneous oscillations in the electrical signals are typically referred to as brain waves or EEG. The EEG is a record derived from the spontaneously oscillating electrical signals and other electrical activity (e.g., "noise" or electrical activity of a non-cerebral origin). As understood by those of skill in the art, the number and configuration of the EEG electrodes **25** and the reference electrodes **28** may depend upon, for example, the subject's medical history, a diagnostic task, etc.

[**0020**] The electrical signals detected by the EEG electrodes **25** and the reference electrodes **28** may be output to a processing unit **30** for analysis. In the exemplary embodiment, the processing unit **30** is disposed on a cross-band of the headband **20** which runs transversely over the scalp. However, those of skill in the art will understand that the processing unit **30** may be disposed anywhere on the headband **20**. The processing unit **30** may amplify, filter and/or digitize the electrical signals and determine whether the electrical signals are indicative of a target brain activity such as an epileptic event. When an epileptic event is detected, the processing unit **30** may activate components of the system **5**, transmit a warning signal(s) to one or more remote computing arrangements (e.g., the computing device **15**, a server, etc.) and save EEG data corresponding to the electrical signals on a storage device (e.g., a removable memory card **32** coupled to the processing unit **30**, a remote database, etc.). Operation of the processing unit **30** will be explained further below.

[**0021**] In the exemplary embodiment, the headband **20** also includes an image capture device (e.g., a video camera **35**, a digital camera). When the headband **20** is worn, the video camera **35** is preferably focused downward so that an imaging field of the video camera **35** includes of the subject's trunk, hands and feet. The video camera **35** may be statically positioned on the headband **20** or moveable and/or rotatable relative thereto. In addition, there may be more than one video camera disposed on the headband **20**. Because the video camera **35** is disposed on the headband **20**, it is preferable that the video camera **35**, as well as the other components of the wearable EEG arrangement **10**, are lightweight and disposed in positions to balance any load imparted to the head.

[**0022**] The headband **20** may further include a radio frequency transceiver **40** for conducting wireless communications, an indicator (e.g., LEDs **45**, speaker, etc.) for providing visual (or audible) signals (e.g., indicating that an epileptic event has been detected), and a battery **50** providing power to the components of the wearable EEG arrangement **10**. The transceiver **40** may allow the processing unit **30** to, for example, exchange data, including the EEG data, warning signals and instructions with the computing device **15**. The LEDs **45** may be activated upon detection of an epileptic event. Upon noticing activation of the LEDs **45**, a nurse, physician or the subject may administer anti-epileptic medication to prevent the occurrence of the epileptic event or reduce the severity thereof. The battery **50** may be a rechargeable battery (e.g., Li ion) or single-use/alkaline which has, for example, a voltage of 3.6V and provides a current of 1000 mA.

[**0023**] As noted above, the system **5** may also include the computing device **15** which is communicatively linked to the wearable EEG arrangement **10**. The computing device **15** may be any processor-based device including, but not limited to, a mobile phone, a PDA, a laptop, a tablet computer, a handheld computer, a PC or any of a number of computers accessed via a network such as the Internet, a WLAN, etc. In other exemplary embodiments, the computing device **15** may simply be a display arrangement such as, for example an LCD display screen or CRT. As will be explained further below, the computing device **15** may be used to monitor EEG data, receive warning signals when an epileptic event is detected, activate the wearable EEG arrangement **10**, etc. The computing device **15** may be further utilized to review the EEG data obtained by from the EEG electrodes **25** and video data captured by the video camera **35** to diagnose the subject, update a previous diagnosis of the subject, prescribe/update a treatment protocol, etc.

[**0024**] In an exemplary use of the system **5**, the wearable EEG arrangement **10** is placed on the head. The reference electrodes **28** are attached to the ears and the EEG electrodes **25** are placed in contact with the scalp. FIGS. **3***a-b* show an exemplary embodiment of an EEG electrode unit **300** which includes one of the EEG electrodes **25** and facilitates attachment of the EEG electrode **25** to the scalp, ensuring that substantially noise- and artifact-free EEG electrical signals are harvested. Each of the EEG electrodes **25** utilized by the wearable EEG arrangement **10** may be included in a respective EEG electrode unit **300**. Thus, a plurality of EEG electrode units **300** may be disposed on the headband **20**.

[**0025**] The EEG electrode unit **300** comprises a housing **305** which holds the EEG electrode **25** and an operational amplifier **310** coupled thereto. An output of the operational amplifier **310** is coupled to a cable **315** which leads to the processing unit **30**. In the exemplary embodiment, the housing **305** may be substantially cylindrical with an open bottom portion and a threaded upper portion. The EEG electrode **25** may fit within the open bottom portion so that a detecting face of the EEG electrode **25** contacts the skin when the headband **20** is worn. A threaded plug **320** mates with the threaded upper portion of the housing **305**. As shown in FIG. **3***a*, rotation of the plug **320** expunges adhesive from one or more channels **325** formed within the housing **305** so that the adhesive exits the channels **325** seeping between the bottom portion of the housing **305** and the skin to form a temporary bond therebetween. Additionally, as the plug **320** is rotated, conductive paste may be expunged from a central channel **330**, seeping between the EEG electrode **25** and the skin to form an electrically conductive bond therebetween. A visual indicator (e.g., green-to-red color change) on the plug **320** may indicate that all of the adhesive and/or conductive paste has been expunged from the EEG electrode unit **300**.

[**0026**] As shown in FIG. **3***a*, an upper portion of the central channel **330** has threads (or other connectors) mating with threads on a central member formed on an underside of the plug **320**. An O-ring **335** disposed circumferentially around the central member prevents backflow of the conductive paste while stoppers **340** in the channels **325** prevent back flow of

the adhesive. Between uses the EEG electrode units **300** may be disposable or reloaded with the adhesive and the conductive paste.

[**0027**] Those of skill in the art will understand that variations may be made to the exemplary embodiments of the EEG electrode units **300** described above without departing from their overall purpose. For example, the plug **320** may utilize a plunging action (syringe-like) to expunge the adhesive and paste. Also, the EEG electrode units **300** may not include the adhesive and/or paste, which may be applied by a nurse or physician. In addition, the operational amplifier **310** may be included as part of the processing unit **30** or otherwise separated from the housing **305**. Alternatively, the signals from the EEG electrode units **300** may be transmitted wirelessly to the processing unit as would be understood by those of skill in the art.

[**0028**] Referring back to the exemplary use of the system **5**, the headband **20** is placed on the scalp and the EEG electrodes **25** are aligned in their proper positions on the scalp. For example, the headband **20** may have a marker (e.g., center of the forehead) which allows the subject to align the EEG electrodes **25** in their proper positions. After the EEG electrodes **25** have been properly aligned, the plugs **320** of the EEG electrode units **300** are rotated to apply the adhesive and the conductive paste to the scalp fixing the EEG electrode units **300** to the target locations and electrically coupling the EEG electrodes **25** to the scalp.

[**0029**] When the EEG electrodes **25** have been secured to the scalp, the wearable EEG arrangement **10** may be powered. In one exemplary embodiment, a switch is provided on the wearable arrangement EEG arrangement **10** which activates the processing unit **30**. In another exemplary embodiment, the processing unit **30** may receive a wireless activation signal from the computing device **15** via the transceiver **40**. When the processing unit **30** is activated, the EEG electrodes **25**, the video camera **35**, and/or the LEDs **45** may be initialized. For example, the processing unit **30** may harvest EEG data from the EEG electrodes **25** and/or the video data from the video camera **35**, and/or flash the LEDs **45**. Segments (e.g., 20 sec) of EEG data and/or the video data may be transmitted to the computing device **15** for display thereon. If the processing unit **30** does not detect an epileptic event, the computing device **15** transmits a monitoring initiation signal to the processing unit **30** via the transceiver **40** instructing the processing unit **30** to being its monitoring and response program.

[**0030**] In the exemplary embodiment, the monitoring and response program utilized by the processing unit **30** is preferably a vector-analysis-based application as described in Kovacs L, Ludvig N., Devinsky O., Kuzniekcy R. I., "Vector-analysis: Low-power-requiring software for real-time EEG seizure recognition/prediction in hybrid neuroprosthetic devices," Epilepsia **46** (Suppl. 8) 317-318 (2005) and U.S. patent application Ser. No. 11/224,661 entitled "Apparatus and Method for Monitoring and Treatment of Brain Disorders," the entire disclosures of which are expressly incorporated herein by reference. The processing unit **30** may monitor the EEG data provided by the EEG electrodes **25** to detect for an epileptic event. Alternatively, any other EEG-seizure recognition software may be employed. However, this may increase the bulk of the system as the power required for other types of software may be greater.

[**0031**] FIG. **2** shows an exemplary embodiment of an architecture **200** of the wearable EEG arrangement **10** according to the present invention. The EEG electrode units **300** and the reference electrodes **28** are electrically coupled to inputs of the processing unit **30**. In this manner, the brain waves are detected and converted into electrical signals by the EEG electrodes **25**. The electrical signals detected by each EEG electrode **25** are passed through a corresponding operational amplifier **310** in the EEG electrode unit **300** to reduce and/or eliminate movement artifacts from the electrical signals. The operational amplifier **310** may be directly coupled to the EEG electrode **25**. The artifact-free electrical signals are then output to the processing unit **30**.

[**0032**] The exemplary processing unit **30** comprises an analog section **205** which receives electrical signals from the EEG electrode units **300** and a digital section **210** which digitizes and analyzes output from the analog section **205** to detect epileptic events. As shown in FIG. **2**, the analog section **205** may include a series of amplifiers **215** (e.g., differential amplifiers) and filters (e.g., band-pass and notch filters **220**) for amplifying and filtering the electrical signals from the EEG electrode units **300**. The analog section **205** may output segments of the electrical signals which are useful in the analysis of epileptic events. The band-pass filters may be preset to a band-pass of 0.5-35 Hz for indicating an ongoing seizure, or to a band-pass of 0.5-200 Hz to indicate both an ongoing seizure and the imminent development of a seizure.

[**0033**] The output of the analog section **205** is passed to the digital section **210** and, in particular, a microprocessor **225** with an analog-to-digital (ADC) converter to digitize the segments of the electrical signals and generate digital EEG data. The digital section **210** may further include a real time clock **230** for time-stamping the EEG data and a field-programmable gate array (FPGA) **235** for controlling and obtaining video data from the video camera **35** and writing the EEG data and/or the video data to the memory card **32**. In the exemplary embodiment, the memory card **32** may be a 512 MB high-speed Secure Digital (SD) memory card, but those of skill in the art will understand that other removable memory arrangements may be used with the wearable memory arrangement **10**, e.g., a CF card, a PCMCIA card, a memory stick, a USB device, a MMC card, an xD-picture card, a smartmedia card, etc. Those of skill in the art will understand that a non-removable may also be utilized.

[**0034**] The digital section **210** may further include a memory (not shown) storing reference data corresponding to EEG data indicative of epileptic events. The reference data may include previous EEG data recorded from the subject or from a group of subjects during one or more epileptic events. Alternatively, the reference data may be a function or other representation which has been constructed based on such EEG data. Alternatively, the memory card **32** may store the reference data tailored for use by a particular subject. In a further embodiment, the computing device **15** may store or have access to the reference data. In this embodiment, the computing device **15**, rather than the processing unit **30**, may detect the occurrence of epileptic events.

[**0035**] In the exemplary embodiment, the microprocessor **225** analyzes the EEG data to detect epileptic events. That is, the EEG data is compared to the reference data to determine whether the subject is experiencing an epileptic event. If the EEG data is not indicative of an epileptic event, the EEG data may be discarded after a predetermined time. For example, a delay may be used so that the EEG data recorded previous to

an epileptic event may be reviewed. Alternatively, all (or selected portions) of the EEG data may be stored on the memory card **32** and/or transmitted to the computing device **15** for long-term analysis.

[**0036**] When the EEG data is indicative of an epileptic event, the processing unit **30** may write the EEG data to the memory card **32** for a predetermined duration (e.g., about 10-30 seconds). Alternatively, the predetermined duration may be selected to correspond to a duration of the epileptic event, i.e., the predetermined time equals the time during which the BEG data is indicative of an ongoing epileptic event. In another exemplary embodiment, the processing unit **30** may continue to write EEG data to the memory card **32** for a predetermined time after cessation of the epileptic event. In this embodiment, anti-epileptic drugs or other seizure treatments may be evaluated for their ability to quell the seizure and/or return the subject to a normal EEG. In other exemplary embodiments, the EEG data may be downloaded (e.g., batch, streamed) to the computing device **15** when the processing unit **30** detects the epileptic event or onset thereof. Thus, a nurse, physician or other caregiver may monitor the EEG data to determine the severity of epileptic events, a proper treatment, etc.

[**0037**] Upon detecting an epileptic event, the processing unit **30** preferably also activates the video camera **35**. As shown in FIG. **4**, the video camera **35** captures video data during the epileptic event. The processing unit **30** may then write the video data to the memory card **32** or download this data to the computing device **15**. The video camera **35** is preferably activated for so long as the EEG data is recorded. Thus, video of the epileptic event may be analyzed in conjunction with the EEG data that was exhibited during the epileptic event. Those skilled in the art will understand that, if memory capacity is sufficient, the video and EEG data may be continuously recorded for later analysis with portions indicative of ongoing to imminent seizure activity flagged.

[**0038**] When an epileptic event has been detected, the processing unit **30** may also transmit a warning signal and/or activate the LEDs **45**. The warning signal may be a wireless signal transmitted to the computing device **15**. Alternatively, the warning signal may be a broadcast signal so that any wireless computing device in range of the transceiver **40** may detect and respond to the warning signal. The warning signal may include data which, for example, identifies the subject (e.g., name, age, etc.), includes medical history data (e.g., diagnosis, treatments, severity, etc.), identifies a location of the subject, etc.

[**0039**] After the EEG data and the video data have been written to the memory card **32**, the memory card **32** may be removed from the wearable EEG arrangement **10** and coupled to the computing device **15**. The EEG data and the video data may then be stored in a database and/or analyzed to determined/update a diagnosis of the subject, prescribe a treatment protocol, etc. Of course, as described above, this data may be transmitted wirelessly to the computing device **15** or via a cabled connection without removing the memory card **32**.

[**0040**] FIG. **5** shows another exemplary embodiment of a wearable EEG system **500** according to the present invention. The wearable EEG system **500** includes a wearable EEG arrangement (e.g., an EEG minidisc **505**) and an image capture device (e.g., a video camera unit **510**). In this exemplary embodiment, the wearable EEG system **500** preferably includes only a single EEG minidisc **505** which performs EEG data acquisition, data analysis and signaling functions while the video camera unit **510** is a separately wearable device which includes a video camera **512** and a transceiver **514** for wirelessly communicating with the EEG minidisc **505**. However, those of skill in the art will understand that the number of EEG minidiscs **505** may vary as desired/prescribed, and that the EEG minidisc **505** may be physically coupled to the video camera **510**, in which case the video camera **510** may not require the transceiver **514**.

[**0041**] As shown in FIGS. **6***a-d*, an EEG minidisc **505** according to an exemplary embodiment of the present invention includes a housing **515** with two EEG electrodes **520** disposed on a bottom surface thereof. A channel **525** extending through the housing **515** from a top surface to the bottom surface allows the conductive paste to be applied to a bottom surface of the EEG electrodes **520**. The adhesive for securing the EEG minidisc **505** to the scalp may also be applied through the channel **525**, through other channels or directly to the scalp and/or to the bottom surface of the housing **515**.

[**0042**] As shown in FIG. **6***d*, a processing unit **530** included in the housing **515** of the BEG minidisc **505** may include one or more amplifiers and filters, in addition to a microprocessor. The processing unit **530** may perform functions similar to those performed by the processing unit **30** described above. That is, the electrical signals obtained by the EEG electrodes **520** may be amplified, filtered (e.g., digital post-filtering) and digitized to generate the digital EEG data, and the EEG data may be analyzed by the microprocessor to detect the occurrence of an epileptic event or the imminent onset thereof, at which time the EEG minidisc **505** may activate the video camera **512**. The processing unit **530** may also transfer the EEG data to a memory on the EEG minidisc **505** and/or transmit the EEG data as a wireless signal (e.g., optical, RF) to a remote computing device.

[**0043**] The EEG minidisc **505** may further include a battery **535**, a battery charging circuit **540**, an optical transceiver **545** and an RF transceiver **550**. The battery charging circuit **540** may be, for example, a magnetic coupling circuit which may be coupled to a charger/data reader to be charged and exchange data with a computing device, as will be described further below. The optical transceiver **545** may be used to exchange data with the computing device, and the RF transceiver **550** may transmit signals to the receiver **514** on the video camera unit **510**. The EEG minidisc **505** may further include an indicator (e.g., LED, speaker, etc.) which is activated upon detection of an occurring or imminent epileptic event.

[**0044**] FIG. **7** shows an exemplary embodiment of an architecture of the EEG minidisc **505** according to the present invention. The EEG electrodes **520** are coupled to the housing **515** and pass, to the processing unit **530**, electrical signals corresponding to detected brain waves. Within the processing unit **530**, the electrical signals are amplified by an amplifier **705** (e.g., an instrumentation amplifier), filtered by a filter **710** (e.g., a band-pass and notch filter) and digitized and processed by a microprocessor **715** (e.g., a low-power micro with a 12 bit ADC) to generate digital EEG data. The microprocessor **715** may then compare the EEG data to reference data stored in a memory **720** (e.g., a non-volatile memory) in the EEG minidisc **505** to determine the occurrence or likelihood of occurrence in the near future of an epileptic event or onset

thereof. When an epileptic event is detected, the microprocessor **715** may transmit an activation signal via the transceiver **550** to the receiver **514** on the video camera unit **510**, activating the video camera **512**. The transceiver **550** may also be used to transmit a warning signal upon detection of the epileptic event. The EEG minidisc **505** may also incorporate an optical transceiver **545** to receive optical activation signals from an optical transmitter.

[**0045**] As shown in FIG. **8**, a video camera unit **510** according to an exemplary embodiment of the present invention resides in a wearable housing **805** which may be, for example, an earpiece, a headband, a cap, etc. The housing **805** may include a microprocessor **810** for activating the video camera **512** upon receipt of the activation signal via the receiver **514**. When the video camera **512** is activated, the microprocessor **810** may write video data obtained by the video camera **512** to a memory **815** (e.g., a removable, non-volatile memory) and download the video data to a wireless communication device (e.g., mobile phone, PDA, laptop, tablet, handheld computer, network interface card, etc.) via a wireless communication circuit (e.g., a cellular phone circuit **820**). Alternatively, upon seizure detection or prediction, the microprocessor **810** may instruct the cellular phone circuit **820** to transmit warning signals to a remote communication device, such as the computing device **15**. The video camera unit **510** may be powered by a battery **825** which is recharged when coupled to a charging device, as described below.

[**0046**] As shown in FIG. **9**, a charger/data reader system **900** according to an exemplary embodiment of the present invention may include a computing device **905** (e.g., a laptop, PC, tablet, etc.) coupled to a multiport charger and data reader (MCDR) **910**. While the MCDR **910** may be used for charging a plurality of EEG minidiscs **505** and/or video camera units **510** simultaneously, those of skill in the art will understand that the MCDR **910** may only accommodate one or a preselected number of EEG minidiscs **505** and/or video camera units **510**. In the exemplary embodiment, the MCDR **910** includes a plurality of charging ports for receiving the EEG minidiscs **505**. When the EEG minidisc **505** is coupled to a charging port on the MCDR **910**, the battery charging circuit **540** receives power from the MCDR **910** and charges the battery **535**. When the video camera unit **510** is coupled to a charging port on the MCDR **910**, the battery **825** may receive power from the MCDR **910**.

[**0047**] When the EEG minidiscs **505** are coupled to the MCDR **910**, the EEG data and the video data may be downloaded from the memory **720** and/or the memory **815** for subsequent uploading to the computing device **905**. The MCDR **910** may further include an RF receiver **915** for wirelessly downloading the EEG data and/or the video data from the EEG minidisc **505** or the cellular phone circuit **820**. In addition, the MCDR **910** may also be equipped with an optical transmitter **920** for activating the EEG minidisc **505** via the optical transceiver **545** of the EEG minidisc. The computing device **905** may utilize EEG processing algorithms and/or image processing algorithms to analyze the epileptic events suffered by the subject.

[**0048**] The present invention has been described with the reference to the above exemplary embodiments. Accordingly, various modifications and changes may be made to the embodiments without departing from the broadest spirit and scope of the present invention as set forth in the claims that follow. The specification and drawings, accordingly, should be regarded in an illustrative rather than restrictive sense.

What is claimed is:

1. A device, comprising:

a head mounting arrangement sized and shaped to be worn on a user's head;

a plurality of electrodes disposed on the arrangement so that, when the arrangement is worn on the user's head, the electrodes contact target portions of a scalp to detect electrical activity of a brain of the user;

an image capture device disposed on the arrangement so that, when the arrangement is worn on the user's head, a field of view of the image capture device includes a portion of an anatomy of the user; and

a processing unit generating EEG data from the electrical activity,

wherein, when the EEG data is indicative of an epileptic event, the processing unit activates the image capture device to capture video data of the user.

2. The device according to claim 1, wherein the arrangement is one of a headband and a cap.

3. The device according to claim 1, wherein the electrodes include at least four electrodes disposed in a predetermined configuration on the arrangement.

4. The device according to claim 1, wherein each of the electrodes is contained in an electrode unit, the electrode unit further comprising an operational amplifier coupled directly to the corresponding electrode.

5. The device according to claim 4, wherein the electrode unit further comprises:

an adhesive delivery arrangement securing the electrode unit to the scalp; and

a conductive paste delivery arrangement applying a conductive paste to electrically couple the electrode to the scalp.

6. The device according to claim 1, wherein the image capture device is one of a video camera and a digital camera.

7. The device according to claim 1, wherein the field of view of the image capture device includes one of trunk, hands and feet of the user.

8. The device according to claim 1, further comprising:

a memory,

wherein the processing unit writes at least a portion of one of the EEG data and the video data to the memory.

9. The device according to claim 8, wherein the memory is a removable memory device.

10. The device according to claim 8, wherein the memory includes reference data corresponding to EEG data obtained from one of the subject and a group of subjects.

11. The device according to claim 10, wherein the processing unit compares the EEG data to the reference data to determine if the user is experiencing the epileptic event.

12. The device according to claim 11, wherein the epileptic event is a seizure.

13. The device according to claim 11, wherein the epileptic event is brain activity preceding a seizure.

14. The device according to claim 1, further comprising:

an indicator activated upon detection of the epileptic event.

15. The device according to claim 14, wherein the indicator is one of a light-emitting diode and a speaker.

16. The device according to claim 1, further comprising:

a wireless transceiver transmitting a warning signal upon detection of the epileptic event to one of a remote display device and a remote computing device.

17. The device according to claim 16, wherein the warning signal includes at least one of (i) identification data identifying the user, (ii) medical history data corresponding to a medical history of the user, (iii) location data indicative of a location of the user, (iv) the EEG data and (v) the video data.

18. The device according to claim 1, further comprising:

a rechargeable battery supplying power to the processing unit, the electrodes, the image capture device and the transceiver.

19. A system, comprising:

an electrode unit attached to a scalp of a subject, the electrode unit comprising:

a plurality of electrodes generating electrical signals corresponding to electrical activity of a brain of the subject;

a processing unit generating EEG data from the electrical signals; and

a wireless transmitter,

an image capture unit worn on a head of the subject, the image capture unit comprising:

an image capture device; and

a wireless receiver,

wherein, when the EEG data is indicative of an epileptic event, the processing unit transmits an activation signal to the image capture unit via the wireless transmitter to activate the image capture device to capture video data of the subject.

20. The system according to claim 17, wherein the electrode unit further comprises:

a rechargeable battery supplying power to the processing unit, the electrodes and the wireless transmitter.

21. The system according to claim 17, wherein the processing unit transmits a warning signal upon detection of the epileptic event.

22. A system, comprising:

a wireless computing device; and

a head wearable arrangement comprising:

a plurality of electrodes disposed on the arrangement so that, when the arrangement is worn on a head in a desired orientation, the electrodes contact target portions of a scalp of the subject to generate electrical signals corresponding to electrical activity of a brain of the subject;

an image capture device disposed on the arrangement, the image capture device capture video data of the subject;

a wireless transceiver; and

a processing unit generating EEG data from the electrical signals,

wherein, when the EEG data is indicative of an epileptic event, the processing unit downloads the EEG data and the video data to the wireless computing device via the wireless transceiver.

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