Title: ARRANGEMENT FOR CARRYING OUT ELECTRODE MEASUREMENTS

Abstract: An object of the invention is an arrangement for carrying out electrode measurements on the surface of the skin of a patient. The arrangement for carrying out at least one hour sleeping time or non-sleeping time electrode measurements comprises a matrix electrode configuration, which comprises a body part (100) of non-conductive material conforming to the contours of the surface of the skin, and which body part (100) comprises an electrode placement configuration (108) for maintaining the mutual placements of the electrodes essentially the same with respect to one another, and which arrangement comprises electrodes being arranged to measure electroencephalography (EEG) signals and electromyography (EMG) signals, at least one electrooculography (EOG) electrode to measure eye movements, at least one electrode (102) attached in the patient’s chest area for carrying out electro cardiac measurements (ECG), and electrodes for performing jaw region measurements, means (104) for transmitting the measurement data obtained by said electrodes, said means (104) for transmitting being connected to the body part (100), and a measurement data unit for receiving the measurement data transmitted by said means (104) for further processing of the measurement data.

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ARRANGEMENT FOR CARRYING OUT ELECTRODE MEASUREMENTS

FIELD OF THE INVENTION

The invention relates to the field of medical technology, more specifically to the arrangement and method for determination of sleep stages, associated events and objective diagnosis of sleep bruxism and other sleep disorders.

PRIOR ART

The gold standard diagnostic method for sleep disorders is attended in-laboratory polysomnography (PSG) but for practical reasons limited-channel sleep recordings (type III portable monitors) are increasingly used as an alternative. These simplified portable monitors typically consist of four to seven channels including at least two respiratory variables (respiratory movement and airflow), cardiac variable (electrocardiogram or heart rate) and arterial oxygen saturation. While portable monitoring offers many undisputable advantages including increased accessibility, better patient convenience and reduced cost, the lack of electroencephalography (EEG) recording causes significant drawbacks. It hinders reliable assessment of total sleep time as well as determination of sleep stages and cortical arousals. This also makes accurate assessment of various indices such as apnea-hypopnea index (AHI, i.e. apneas plus hypopneas per hour of sleep) impossible. To overcome above mentioned problems, an increasing number of portable devices designed for unattended full PSG studies (i.e. type II devices, including EEG channels) has been introduced. Type II devices are intended to offer a complete sleep evaluation in an attended surrounding at patients' home, allowing not only the diagnosis of sleep disordered breathing, but also other sleep disorders like periodic leg movements during sleep, central sleep apnea, insomnia and sleep bruxism. Although recent technological advances have al-
allowed for a significant reduction in the size and weight of portable monitors, there are still some technical issues, particularly related to separately attach-
able complicated electrode systems used to record EEG, electrooculography (EOG) and electromyography (EMG) signals that limits the widespread use of home PSG. When considering in-home monitoring, attachment of separate electrodes, especially at hairy skin sites is too complicated.

Sleep is divided into two broad types: rapid eye movement (REM sleep) and non-rapid eye movement (NREM sleep). The American Academy of Sleep Medicine (AASM) divides NREM sleep further into three stages, i.e. N1, N2, and N3. Each stage has a distinct set of physiological and neurological features associated with it. The scoring of sleep stages in PSG is based on visual inspection of EEG, EOG and chin EMG signals. Currently, the EEG is most commonly recorded by using separate cup electrodes located according to the internationally standardized, so called 10-20 system. To ensure high quality data, there are three key issues that need to be taken into account, i.e. electrodes must be placed in the correct location, skin sites must be properly prepared, and electrodes must be securely attached. According the latest AASM recommendation, there are six scalp electrodes to measure EEG in PSG: two frontal electrodes (F3 and F4), two central electrodes (C3 and C4), and two occipital electrodes (O1 and O2). In addition, two mastoid electrodes M1 and M2 are used as reference electrodes. The primary recording derivations are F4-M1, C4-M1 and O2-M1. Furthermore another set of electrodes are attached to another side of scalp in order to record the back-up derivations F3-M2, C3-M2 and O1-M2. The AASM also recommends the use of left and right EOG derivations (E1-M2 and E2-M2) and chin EMG (primary channel and back-up channel). Attaching cup electrodes on the scalp sites requires preparation of the skin, that is, mechanical scraping of the skin to remove the dead surface layer (epidermis), and dosing of a conductive me-
dium (electrode gel). Finally, the adhesion of the electrodes is ensured by different attachment systems, such as tapes, bands, nets, caps or adhesive
fixing paste. The preparations for measurement thus require a lot of experience and special know-how. A measuring wire connected to each electrode makes the measuring connection rigid and uncomfortable, hindering the patient's normal movements and sleep, and may thus cause motion artefacts and other interferences in the measuring signal and thus complicate the interpretation of the sleep recording data. It is easily understood that this kind of electrode setup is not suitable for patient self-application.

There are simple disposable electrode strips commercially available (e.g. in patent publication EP0951233B1), which are adhered to the patient's forehead and mainly used for determining the depth of anesthesia during operations. However, due to the small number (1-4) of electrodes and their locations, such a solution is not suitable for scoring of sleep stages.

One prior art solution is a quick-to-use electrode set (StatNet™, HydroDot Inc., WO2009/061920A1), which consist of two strips placed crosswise over the head. The flexible plastic strips have a sandwich structure with integrated silver silver chloride electrodes and silver signal transmission lines. The strips are coated with an adhesive by means of which the sensor adheres to the skin. On top of the electrodes, there is a porous pre-moistened pad construction. Thus no skin preparation is required. The operating time of the electrode is said to be 4 hours. This prior art implementation in question may be suitable for paramedic and intensive care unit use, but not for several other EEG examinations, such as long-term sleep studies. Especially that is not suitable for patient self-application.

Bruxism is defined as a repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible. Bruxism has two distinct circadian manifestations: it can occur during sleep (indicated as sleep bruxism) or during wakefulness (indicated as awake bruxism). Sleep bruxism is associated with a number of clinical problems,
including muscle and joint pain, awakening headache, dental damage and loss of dental implants. Several methods are used in the diagnostics of sleep bruxism. A recent international consensus statement proposed a new diagnostic grading system of "possible", "probable", or "definite" SB depending on diagnostic technique employed. Self-reported questionnaires yield only a 'possible' diagnosis of bruxism. In addition to simple self-report, clinical evaluations may be utilized that include an examination of wear patterns of the teeth combined with patient interview yielding probable diagnosis of sleep bruxism. Polysomnography (PSG) is the gold standard method for assessment of sleep bruxism. During PSG studies, electromyographic (EMG) activity of the masticatory muscles can be monitored, and audiovisual monitoring can differentiate between rhythmic masticatory muscle activity (RMMA) associated with sleep bruxism and other orofacial activity, including movement artefacts. In-lab PSG is the most reliable method yielding "definite" diagnosis of sleep bruxism but unfortunately this technique is applicable only to a small fraction of patients due to the high cost and limited availability. Better solutions are needed for wide use and screening.

During the last years, some portable electromyographic (EMG) devices have been introduced in order to solve the limitations in current diagnostics of sleep bruxism. The BiteStrip (Up2dent, Koln, Germany) is a miniature sleep EMG monitor, including two pre-gelled EMG electrodes attached to the patient's cheek. Despite of its simplicity, there is a significant risk of overestimating the number of true sleep bruxism episodes because such devices do not record other sleep bruxism markers e.g. related to autonomic activity. Recent studies have demonstrated that the sleep bruxism event is preceded in particular by a sudden shift in autonomic cardiac and respiratory activity as well as by a specific brain activation. The Bruxoff (SpesMedica, Genova, Italy) is a three channel portable monitor able to simultaneously record EMG activity bilaterally from the masseter muscles and the heart frequency. However, this system is not suitable for determination of sleep architecture or for
detection of neurophysiological phenomena recently known to be associated with sleep bruxism. The etiology of sleep bruxism is multifactorial and still partly unknown. In the past, different morphological factors, like occlusal discrepancies and the anatomy of the bony structures, have been considered as main factors for bruxism. However, recent studies have given evidences that these factors play only a small role, if any. Sleep bruxism appears to be mainly regulated centrally, not peripherally. Sleep bruxism has been suggested to be part of a sleep arousal response and it seems to be modulated by various neurotransmitters in the central nervous system. Therefore, a simple method able to record electrical activity of the brain (EEG) in addition of EMG and ECG is required to allow reliable diagnostics of sleep bruxism for clinical and research purposes.

The patent publication US8588883B2 relates to a method and an apparatus for monitoring activity of the temporal and/or masseter muscle, in particular temporal and/or masseter muscle activity due to bruxism. The electrode assembly comprises three electrodes in a fixed spatial relationship one to another. However, this electrode measurement arrangement does not include electrodes located on the area of forehead, chin or chest to enable the recording of electrical activity of the brain or muscles or heart, respectively. Due to these shortcomings this arrangement is not suitable to reliable determination of sleep stages or objective diagnosis of sleep bruxism.

In patent application WO2014072582A1, is presented an arrangement for carrying out electrode measurement on the surface of skin of a patient's head for recording the electrical activity of the brain. This arrangement comprises a matrix electrode configuration comprising a body part of non-conductive material conforming to the contours of the surface of the skin. The arrangement comprises electrodes for producing the measurement data connected to the said body part, means for transmitting said measurement data and a measurement data unit for receiving said measurement data for
further processing. The body part comprises an electrode placement configuration for maintaining the mutual placement of the electrodes essentially the same with respect to one another and further comprises an active attachment surface located between the electrodes and the surface of the skin for forming a firm and electro-conductive contact between the electrodes and the surface of the skin. However, this electrode measurement arrangement does not include electrodes located on the area of chin or cheeks to perform the recording the electrical activity measurement of muscle activity. Due to these shortcomings this arrangement is not suitable to reliable determination of sleep stages or objective diagnosis of sleep bruxism.

**BRIEF DESCRIPTION OF THE INVENTION**

The aim of this invention is to eliminate and reduce the problems relating to the prior art measurement systems and to allow reliable sleep bruxism and other polysomnography studies cost-efficiently at home. In other words, the aim of the invention is to realize an electrode measurement implementation for determining the sleep architecture and sleep bruxism events by recording simultaneously electroencephalography (EEG), electrooculography (EOG) and electromyography (EMG) signals. This is achieved by an arrangement for carrying out electrode measurements on the surface of the skin of a patient, the arrangement comprising electrodes for producing measurement data and an active attachment surface located between the electrodes and the surface of the skin for forming a firm and electroconductive attachment contact between the electrodes and the surface of the skin for transmitting measurable signals from the patient to the electrodes through said electroconductive active attachment surface to produce measurement data, said electroconductive active attachment surface comprising hydrogel or other electroconductive adhesive material which adheres well to the skin in order to form a stable and essentially interference-free attachment contact between the electrodes and the skin surface. The arrangement for carrying out at least one
hour sleeping time or non-sleeping time electrode measurements comprises a matrix electrode configuration, which comprises a body part of non-conductive material conforming to the contours of the surface of the skin, and which body part comprises an electrode placement configuration for maintaining the mutual placements of the electrodes essentially the same with respect to one another, and which arrangement comprises electrodes being arranged to measure electroencephalography (EEG) signals and electromyography (EMG) signals, at least one electrooculography (EOG) electrode to measure eye movements, at least one electrode attached in the patient's chest area for carrying out electro cardiac measurements (ECG), and electrodes for performing jaw region measurements, means for transmitting the measurement data obtained by said electrodes, said means for transmitting being connected to the body part, and a measurement data unit for receiving the measurement data transmitted by said means for further processing of the measurement data.

The invention is based on a matrix electrode configuration, which comprises a body part of non-conductive material conforming to the contours of the surface of the skin, and an electrode placement configuration for maintaining the mutual placements of the electrodes essentially the same with respect to one another. The invention is further based on electrodes which are arranged to measure electroencephalography (EEG) signals and electromyography (EMG) signals, at least one electrooculography (EOG) electrode to identify eye movements, at least one electrode attached in the patient's chest area for carrying out electro cardiac measurements (ECG), and electrodes for performing jaw region (EMG) measurements.

Extensive sweating on fore head and tempus areas can cause shortcircuiting or detachment of electrodes. To prevent the phenomena, these large areas surrounding electrodes are preferably perforated or semipermeable or composed of water vapor transparent films to allow easy removal of moisture by
water vapor evaporation. This kind of perforation or similar may be implemented on the body part 100, but excluding the areas of the active electrodes 110a.

The benefit of the invention is that it enables carrying out simultaneous electroencephalography (EEG), electromyography (EMG), electrooculography (EOG), cardiac measurements (ECG), and jaw region measurements by so simple and easy measurements that a patient even can set up the whole system by itself at home, which makes easy overnight recording possible and affordable.

**BRIEF DESCRIPTION OF THE FIGURES**

Fig. 1 presents an exemplary assembly on patients face according to present invention.

Fig. 2 presents an exemplary matrix electrode configuration according to the present invention.

Fig. 3 presents one preferred embodiment according to the present invention.

Fig. 4 presents one exemplary embodiment about the details of the electrode structure.

**DETAILED DESCRIPTION OF THE INVENTION**

The invention is further described based on the accompanied figures.

In Fig. 1 a facial assembly is presented. The assembly may be e.g. in connection with a breast collar. Further, the patient may be connected e.g. to
electrocardiography sensors, a pulse oximeter and/or respiratory effort belts detecting the movements of chest and abdomen and/or nasal cannula pressure transducers detecting respiratory airflow. The plurality of sensors may be integrated into one measurement system. Further sensors may be integrated also with the body part 100 of the present invention.

In Fig. 2 is shown an embodiment with three separate connectors according to the present invention.

In Fig. 3 is shown an embodiment with one connectors according to the present invention.

In Fig. 4 is presented a more detailed look at the electrode structure. The electrodes 102 are spiral shaped and of conductive silver. The means 104 for transmitting are surrounded by an insulation 106. The attachment surface 110a, shown in an exploded view to make the inner structure of the electrodes and transmitting means visible, is of hydrogel and the areas of the body part 100 nearby the electrodes 102 are of medical foam 110b.

Further, the electrodes may be shaped as platy (as disclosed in Figs. 2 and 3), spiral (as in Fig. 4) dactylate, meshy or such. They may also said to be disc, elliptic disc, ring, finger-like shape, snake-like shape or spiral shape.

In the present invention, an arrangement for carrying out electrode measurements on a surface of skin of a patient is arranged. The arrangement comprises electrodes 102 for producing measurement data and an active attachment surface 110 located between the electrodes 102 and the surface of the skin for forming a firm and electroconductive attachment contact between the electrodes and the surface of the skin for transmitting measurable signals from the patient to the electrodes through said electroconductive active attachment surface 110 to produce measurement data. Said electrocon-
ductive active attachment surface 110 comprises hydrogel or other electro-conductive adhesive material which adheres well to the skin in order to form a stable and essentially interference-free attachment contact between the electrodes 102 and the skin surface.

The arrangement according to the present invention is arranged for carrying out at least one hour sleeping time or non-sleeping time electrode measurements. The arrangement comprises a matrix electrode configuration, which comprises a body part 100 of non-conductive material conforming to the contours of the surface of the skin. In figure 2 is presented an exemplary matrix electrode configuration according to the present invention. The body part 100 comprises an electrode placement configuration 108 for maintaining the mutual placements of the electrodes essentially the same with respect to one another. The arrangement according to the present invention comprises electrodes being arranged to measure electroencephalography (EEG) signals and electromyography (EMG) signals, at least one electrooculography (EOG) electrode to measure eye movements, at least one electrode 102 attached in the patient's chest area for carrying out electro cardiac measurements (ECG), and also electrodes for performing jaw region measurements. The arrangement further comprises means 104 for transmitting the measurement data obtained by said electrodes, said means 104 for transmitting being connected to the body part 100, and the arrangement comprises a measurement data unit for receiving the measurement data transmitted by said means 104 for further processing of the measurement data. The means 104 for transmitting the measurement data can be implemented by wired or wireless signal transmission techniques. The wireless means 104 comprises transmitter for sending the measurement data and a receiver for receiving the measurement data. The wired means 104 that comprise transmission lines, in which the measurement data is transmitted. Said lines 104 can be e.g. optical cables or electrical wires.
In one preferred embodiment of the invention the electrodes are made of Ag/AgCl surrounded by a hydrogel collar or ring. Further, the breathing movements are detected by respiratory effort belts fastened around the chest and/or abdomen. Further, respiratory airflow can be detected by nasal cannula pressure transducers. It is still one embodiment of the invention for the sensors further to include a thermistor located in front of patients mouth.

It is another preferred embodiment of the invention to prepare the large areas surrounding the electrodes (102), excluding the areas of the active electrodes, of the body part (100) as perforated and/or semipermeable for preventing the extensive sweating.

In another preferred embodiment according to the present invention the body part 100 can comprise an electrode placement configuration 108 for maintaining the mutual placements of the electrodes 102 essentially the same with respect to one another for easy attachment of the matrix electrode construction in the hairless skin areas of the patient's head by means of the active attachment surface 110. Each electrode attaches to its intended measuring point in the said hairless skin areas of the head. The active attachment surface can comprise an electroconductive surface 110a and a non-conductive surface 110b. Further, the electrode placement configuration may include the placement of electrodes E1 and E2 on the level of the patient's eyes and the orientation of the electrodes LM1 and LM2 is such that they are parallel to the muscle fibres. Further, the distance of the electrodes may be optimized such, that they both are on a muscle for maximizing the signal intensity.

In this context, the word "hair" is supposed to mean only the hair growing from persons head, which can grow into length of dozens of centimeters if not specifically cut. This term should not be understood to mean the fluffy skin hair around the human body, neither is it supposed to mean any facial
fair or other male or female typical hair growth on the skin. It is to be understood, that the hairless areas of the skin can include skin hair or facial hair.

In embodiments according to present invention the arrangement for carrying out electrode measurements can comprise an optimised electrode configuration to provide an essentially good signal-to-noise ratio (S/N), as well as magnetic resonance imaging (MRI) and computed imaging (CT) compatibility. The arrangement for carrying out electrode measurements can comprise integrated wiring and measurement electronics enabling patient to use the arrangement independently. In figure 3 is presented one preferred embodiment according to the present invention in which electrodes and transmission lines are incorporated into a solid body. Only one connector is then needed.

In figure 2 is presented one preferred embodiment of an arrangement for carrying out measurement for determination of sleep stages and detecting of sleep bruxism events according to the present invention. The arrangement comprises a matrix electrode configuration, which comprises a body part 100 of non-conductive material conforming to the contours of the surface of the skin. Electrodes 102 are produced e.g. using screen printing technique on the body part for picking bio-signals (e.g. EEG, EOG, EMG, ECG) from human body. The transmission lines 104 for transferring the measurement data are also connected to the body part. The transmission lines are, for example, screen-printed silver conductor lines which transfer bio-signals from electrodes to e.g. crimped type quick connector through which the measurement data is transmitted further through a wire or wirelessly to a measurement data unit for further processing. The measurement and storage data unit is, for example, sleep monitor attached to the patient's chest, through which measurement data is further transferred to computer unit for scoring and diagnostic examinations.
The breathing movements can be detected by a respiratory effort belts fastened around the chest and/or abdomen. Further, respiratory airflow can be detected by nasal cannula pressure transducers. The sensors may further include a thermistor located in front of patients mouth. The attachment of nasal cannula/thermistor can be integrated with the body part 100 of the present invention. Additionally, further sensors may be added in the system. These are exemplary EMG electrodes located on the legs to detect movement of legs, especially for restless leg syndrome; inertia sensors for motion tracking and/or sleep position; temperature sensor, for body temperature; sensors for measuring galvanic skin response; snoring sensors; and transcutaneous CO₂ sensors. These sensors can be connected either by wired or wirelessly to a measurement data unit for further processing.

The body part 100 according to the invention comprises an electrode placement configuration 108, by means of which the mutual placements of the electrodes are maintained essentially the same with respect to one another. Electrodes 102 attached to the solid body part are adhered preferably on the patient's forehead, temple, cheek, jaw and behind the ears. In addition, the arrangement for carrying out electrode measurements may comprise at least one electrode attached in the patient's chest area for carrying out electrocardiac measurements (ECG). Alternatively, heart rate, heart rate variability (HRV), pulse wave amplitude (PWA) and such parameters can be obtained via finger pulse oximetry.

Separate gels or electrode pastes are not needed and cannot be used for attachments according to the present invention. The active attachment surface 110 based on hydrogel immediately provides a stable contact with the skin which may last over the night. From the point of view of manufacturing technique and structure, the matrix electrode is relatively simple and economical and thus suitable to be disposable. The matrix electrode is delivered sterilized in a disposable package.
The matrix electrode configuration according to the invention can be formed, for example, by a method of implementation based on screen printing technique. As the body part (base layer) of the matrix electrode is used a thin polymer film, such as Mylar, Kapton, polyester, polyethene, polypropene or polyimide film, which conforms to the contours of the face. The electrodes and their transmission lines are thick-film structures made of conductive ink (e.g. Ag, Ag/AgCl, graphite, graphene ink etc.) on the surface of the Mylar film. The body part of the matrix electrode is coated with insulating material (insulant layer) to avoid short-circuiting of the wires. In the insulating material are openings at the electrodes, through which the electrode spots are in contact with the hydrogel (for example, AG602, Amgel Technologies, Fallbrock, CA, USA). To ensure firm attachment, it is possible to add non-conductive hydrogel or other adhesive material around each electrode. The hydrogel layer is covered with a protective layer (release liner layer) which gives support during the mounting of the electrode. The release liner layer also protects the electrodes from drying; the film may be, for example, a thin plastic film, which is torn off at the stage when the attachment of the electrode is begun.

All transmission lines 104 preferably end in the projecting part of matrix electrode, from which the recorded bio-signals are guided by means of a quick coupling to an amplifier/sleep monitor. In one preferred embodiment, there are three separate signal strips/crimp connectors (Fig. 2).

In one preferred embodiment according to the invention of an arrangement for carry out measurement for determination of sleep stages and detecting of sleep bruxism events consists of total of 17 electrodes (Fig. 2). From these electrodes, there are six EEG electrodes (Fpl, Fp2, Af7, Af8, T9, T10, see figure), two EOG electrodes (E1, E2), and bipolar electrode pairs for measuring the electrical activity of masseter muscles (LM1, LM2), reference elec-
trade (Ref) and ground electrode (Gnd). If necessary, it is possible to use T9 and T10 as a reference or connect Ref and Gnd together in a measuring device or in the electrode embodiment. This increases the contact area of grounding and may improve the signal quality. Furthermore, in this embodiment, a separate electrode set for measurement of electrical activity of chin muscle (EMG1, EMG2, EMGF) is used. It is clear that this chin muscle set can also be incorporated in the main part of the matrix electrode configuration. (Fig. 3)

In one preferred embodiment, the Ag/AgCl electrodes 102 are integrated on the body part 100. On the insulation, there is a hole in the same location. The size if the structure is preferably about 6mm-10mm, more preferably about 7mm-9mm and most preferably approximately 8mm. The size of the hydrogel disc above the electrode may be about 22mm-26mm, more preferably 23mm-25mm, and most preferably approximately 24mm. The width of the transmission lines is preferably 0.5mm-1.5mm, more preferably 0.75mm-1.25mm and most preferably approximately 1.00mm. The size or diameter of the central area of the electrodes T9 and T10 may typically be approximately 20mm.

In view of the exemplary implementations presented in figures 2 and 3, it is obvious to a person skilled in the art that the matrix electrode described in the invention can be implemented with very different techniques, for example, with thin film and lithographic methods, silk-screen printing technique, printing techniques, various lamination techniques, etc. The arrangement according to the invention for carrying out electrode measurements can be utilized and used, for example, in the following applications.

Next is presented four different exemplary applications according to the present invention.
In the first exemplary application is presented sharpening the diagnostics of sleep apnea. It is well-known that the accurate determination of total sleeping time (TST) is one of the major limitations in present portable sleep monitoring not allowing EEG recording, possibly leading to underestimation of AHI and misclassification of the severity of sleep apnea. Furthermore, lack of EEG recording in portable monitors precluded scoring of hypopneas associated with arousals and therefore only a subset of hypopneas could be scored. This may also lead to underestimation of the severity of sleep apnea. Particular merit of invention is a very accurate determination of TST that enables reliable determination of many sleep indices such as apnea-hypopnea index (AHI, events/h) that uses TST as the denominator. The present invention therefore offers a significant advancement in portable sleep studies.

In the second exemplary application is presented full polysomnography at home conditions. There is a growing trend to move full PSG studies from sleep laboratories to home. Monitoring at home offers many advantages such as increased accessibility, better patient convenience and reduced cost. However, current electrode systems, particularly those used in EEG, are too cumbersome for patient self-application. Since this invention is easy and quick to apply, it is especially useful for portable home monitoring enabling electrode self-application and administration of whole testing without the need of nurse/sleep technician. This kind of application is especially beneficial for patients with narcolepsy, insomnia, parasomnia or similar.

In the third exemplary application is presented bruxism monitoring. In-lab PSG is the most reliable method yielding "definite" diagnosis of sleep bruxism but unfortunately this technique is suited only small samples due to the high cost and limited availability. There is a need to move PSG studies from sleep laboratories to home. This invention is particularly useful in objective diagnosis of sleep bruxism. The invention makes simultaneous measurement of EEG, EOG, ECG and EMG signals possible with a simple matrix electrode that
is easy and quick to apply. The simple construction of the invention enables, that the patient can perform electrode self-application and administration of whole testing without the need of nurse/sleep technician. The recording can be therefore carried out in the natural patient environment, at home. The invention enables reliable sleep bruxism investigations yielding "definite" diagnosis of sleep bruxism without the limitations of high cost and poor availability of present gold standard methodology.

In the fourth exemplary application is presented an electrode system in full polysomnography studies in hospital settings. The full polysomnography set-up consists of electroencephalography (EEG), electrooculography (EOG) and chin electromyography (EMG) recording to allow determination of sleep stages and cortical arousals. Since the invention is easy and quick to apply, it is particularly useful for studies carried out outside the particular sleep laboratories since no special neurophysiological expertise and skills are required to place it, in contrast to prior the art electrodes.
CLAIMS

1. An arrangement for carrying out electrode measurements on the surface of the skin of a patient, the arrangement comprising electrodes (102) for producing measurement data and an active attachment surface (110) located between the electrodes (102) and the surface of the skin for forming a firm and electroconductive attachment contact between the electrodes and the surface of the skin for transmitting measurable signals from the patient to the electrodes through said electroconductive active attachment surface (110) to produce measurement data, said electroconductive active attachment surface (110) comprising hydrogel or other electroconductive adhesive material which adheres well to the skin in order to form a stable and essentially interference-free attachment contact between the electrodes (102) and the skin surface, characterized in that the arrangement for carrying out at least one hour sleeping time or non-sleeping time electrode measurements comprises a matrix electrode configuration, which comprises a body part (100) of non-conductive material conforming to the contours of the surface of the skin, and which body part (100) comprises an electrode placement configuration (108) for maintaining the mutual placements of the electrodes essentially the same with respect to one another, and which arrangement comprises electrodes being arranged to measure electroencephalography (EEG) signals and electromyography (EMG) signals, at least one electrooculography (EOG) electrode to measure eye movements, at least one electrode (102) attached in the patient's chest area for carrying out electro cardiac measurements (ECG), and electrodes for performing jaw region measurements, means (104) for transmitting the measurement data obtained by said electrodes, said means for transmitting being connected to the body part (100), and a measurement data unit for receiving the measurement data transmitted by said means (104) for further processing of the measurement data.
2. An arrangement as claimed in claim 1, characterized in that the electrodes are made of Ag/AgCl surrounded by a hydrogel collar or ring.

3. An arrangement as claimed in claim 1, characterized in that the breathing movements are detected by respiratory effort belts fastened around the chest and/or abdomen.

4. An arrangement as claimed in claim 1, wherein respiratory airflow is detected by nasal cannula pressure transducers.

5. An arrangement as claimed in claim 3, wherein the sensors further includes a thermistor located in front of patient's mouth.

6. An arrangement as claimed in claim 1, wherein the large areas surrounding the electrodes (102), excluding the areas of the active electrodes, of the body part (100) are perforated and/or semipermeable for preventing the extensive sweating.

7. An arrangement as claimed in claim 1, characterized in that the body part (100) comprises an electrode placement configuration (108) for maintaining the mutual placements of the electrodes (102) essentially the same with respect to one another for easy attachment of the matrix sensor construction in the hairless skin areas of the patient's head by means of the active attachment surface (110), each electrode attaching to its intended measuring point in the said hairless skin areas of the head.

8. An arrangement as claimed in claim 7, characterized in that the electrode placement configuration includes the placement of electrodes (EL; E2) on the level of the patient's eyes and the orientation of the electrodes (LM1; LM2) is such that they are parallel to the muscle fibres.
9. An arrangement as claimed in claim 1, **characterized** in that the active attachment surface (110) comprises an electroconductive surface (110a) and a non-conductive surface (110b).

10. An arrangement as claimed in claim 1, **characterized** in that the arrangement for carrying out electrode measurements comprises an optimised electrode configuration to provide an essentially good signal-to-noise ratio (S/N), as well as magnetic resonance imaging (MRI) and computed imaging (CT) imaging compatibility.

11. An arrangement as claimed in claim 1, **characterized** in that the arrangement for carrying out electrode measurements comprises integrated wiring and measurement electronics enabling patient to use the arrangement independently.
INTERNATIONAL SEARCH REPORT

International application No
PCT/FL2015/050676

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/0408 A61B5/0478 A61B5/0492 A61B5/0496 A61B5/00
A61B5/0428
ADD. A61B5/04

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category Citation of document, with indication, where appropriate, of the relevant passages Relevant to claim No.


Further documents are listed in the continuation of Box C. See patent family annex.

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