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(54) Sensor arrangement

(57) Sensor arrangement for measuring anesthesia parameters from the head of a patient the sensor arrangement comprising a base element (9) and an array of electrodes and an optical sensor (7) for monitoring substances in tissues. In the sensor arrangement all electrodes and sensors are connected to a single connector (10) or a series of connectors attached to the base element (9) for connecting the sensor arrangement to a patient monitor.

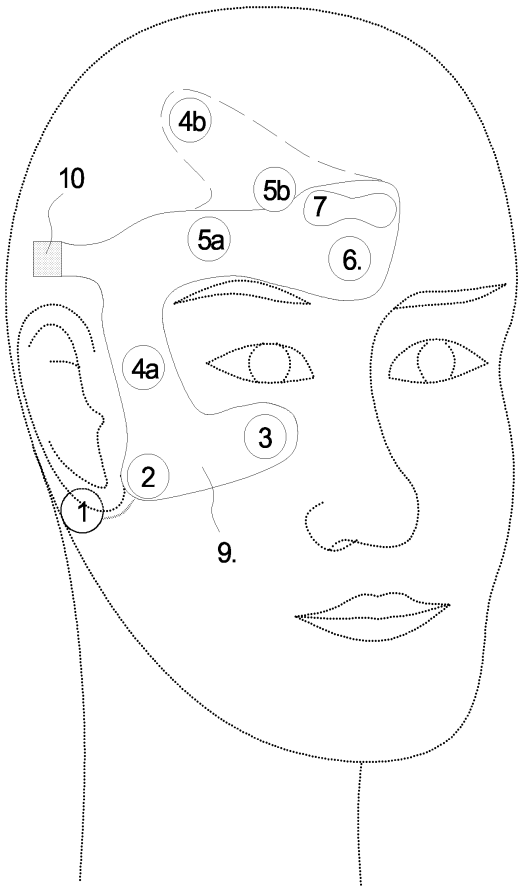

Figure 1. The first embodiment.

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Description

[0001] The present invention relates to measuring anesthesia parameters from the head of a patient.

[0002] The parameters widely used in anesthesia are Entropy, which is derived from EEG and FEMG signals, and NMT and SpO2. Currently the Entropy parameter is the only parameter, which is exclusively measured from the head of the patient. SpO2 is sometimes measured from the ear if extremities cannot be used. So far NMT is mainly monitored from the hand. The parameters mentioned above can be described shortly as follows.

[0003] SpO2 or pulse oximetry measures the oxygenation of the blood noninvasively. Blood absorbs red and infrared light differently depending on the oxygenation, ie. the colour of the blood varies with its oxygenation. By emitting red and infrared light through tissue and measuring the absorption of the two different wavelengths (red, about 660 nm and infrared, about 940 nm) the blood oxygenation can be calculated. There are two ways of doing this, transmission oximetry or reflectance oximetry. In transmission oximetry the emitter (two LEDs) and receiver (photodetector) are placed facing each other typically on each side of a finger, toe or earlobe. In reflectance oximetry the light is reflected below the tissue (eg. Chest, forehead or limbs) back to the same surface as the emitter. This way both the emitter and receiver can be palced on the same skin surface. These matters are described in "Chemical Biosensors", Peura, R.A., Webster J.G. (ed.), Medical Instrumentation: Application and Design. New York: Wiley, 1998, pp. 469-472.

[0004] Neuro Muscular Transmission (NMT) is the transfer of an impulse between a nerve and a muscle in the neuromuscular junction. NMT can be blocked by neuromuscular blocking agents-drugs, which cause transient muscle paralysis and prevent the patient from moving and breathing spontaneously. Muscle relaxation is used during general anesthesia to enable endotracheal intubation and to provide the surgeon with optimal working conditions. The level of neuromuscular block is routinely measured by stimulating a peripheral nerve, usually in the hand, and by evaluating the muscle response. The muscle response can be measured either visually, by touching the hand, using a mechanical piezoelectric sensor or measuring the EMG response (ie. electrical muscle activity). These matters are described in "A Practical Guide to Monitoring: Neuromuscular Function", Sorin J. Brull et al, Datex-Ohmeda, 2002.

[0005] Neuromuscular transmission can also be measured from the face of the patient by stimulating the facial nerve and observing the response of the facial muscles. These matters are described in the article "Comparison of Neuromuscular Blockade in Upper Facial and Hypothenar Muscles", Paloheimo Markku P.J. et al, Journal of Clinical Monitoring, Vol 4, No 4, Little, Brown and Company, October 1988.

[0006] The entropy parameter is used to determine the level of hypnosis of an anesthesized patient. The Entropy parameter is based on EEG and EMG signals measured from the forehead of the patient. The EEG signal represents brain activity whereas EMG represents muscle activity. Entropy could be described as the level of irregularity in the EEG and EMG signals. When the patient is awake, there is more brain and muscle activity whereas an anesthesized patient has less brain and muscle activity. These matter are described in the PCT-document WO 02/32305 A1.

[0007] A considerable problem in the operating rooms is the large amount of cables and hoses extending from the patient to a patient monitor and other devices connected to the patient. The amount of cables and hoses is due to the fact that traditionally separate sensors have been connected for example to a patient monitor using a cable of its own or a hose of its own. This principle leads to a considerable amount of cables and hoses, which may cause difficulties in the operating rooms particularly in extreme situations.

[0008] The object of the invention is to provide a sensor arrangement by which the problems of the prior art technique can be eliminated. This is obtained by the invention. The basic idea of the invention is that all electrodes and sensors are connected to a single connector or alternatively to a series of connectors for connecting the sensor arrangement to a patient monitor.

[0009] The sensor described herein provides a combination of the basic adequacy of anesthesia parameters into one compact sensor. The sensor gives a significant improvement to the current level of ergonomics and usability. When using the invention the user only has to attach one sensor instead of three separate sensors, Entropy, NMT and SpO2. In addition all parameters are measured from the same area, the face of the patient. There is no need to attach any sensors on the hands of the patient, which would typically be the case for NMT and SpO2. The user also only needs to connect one cable to the sensor since all parameters are connected through one connector. Depending on the sensor design, it might be necessary to use separate connectors for some of the parameters to meet patient leakage current and isolation requirements.

[0010] As told above a considerable problem in the operating rooms using the prior art technique is the large amount of cables and hoses extending from the patient to the patient monitor and other devices connected to the patient. The present invention eliminates or at lest drastically reduces said problem by combining several parameters into one cable and thereby reducing the "cable clutter".

[0011] Currently the Entropy parameter is the only parameter, which is exclusively measured from the head of the patient. SpO2 is sometimes measured from the ear if extremities cannot be used. So far NMT is mainly monitored from hand, but in fact the face offers a good alternative location for NMT measurement. Since Entro-

py can also be measured from the forehead of the patient, the head is a logical location for the combined sensor. The Entropy electrodes are located on the forehead and temple area.

[0012] Electrodes are also used for NMT stimulus and can also be used for NMT measurement (muscle response is measured by measuring the EMG response). To reduce the number of electrodes needed, some of the Entropy and NMT electrodes can be shared between the two parameters. The measurements can then be multiplexed to stimulate and measure potentials for the two different parameters. NMT can be measured either using a mechanical sensor sensing physical muscle movement or using electrodes measuring muscle activity electrically (EMG). Using a mechanical sensor requires a separate piezo-electric sensor over the muscle where the response is to be measured.

[0013] SpO2 is typically measured from the extremities or from the ear. It is, however, possible to measure SpO2 anywhere on the body where you can place an optical emitter and detector in such a fashion that the emitted light passes through oxygenated tissue. On the head of the patient such areas are the ears and the nose, and if the light is reflected off the scull, the forehead can be used as well.

[0014] All parameters in the combined adequacy of anesthesia sensor can be reliably recorded from the head of the patient enabling a compact sensor. It is also possible to evaluate the amount of pain experienced by the patient (analgesia) by monitoring the heartrate and the amplitude of the plethysmographic curve (signal obtained from the SpO2 sensor). The analgesia parameter could also be derived from the SpO2 signal without additional sensors.

[0015] In the following the invention will be described in greater detail by means of the examples shown in the drawings enclosed. The Figures 1 - 11 describe eleven different embodiments of the invention.

[0016] The first embodiment of the invention is described in Figure 1. The sensor arrangement shown in Figure 1 comprises an array of electrodes for measuring EEG, EMG and NMT. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. If location b is used, electrode 4a is also used. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. The International 10-20 system is described in "Monitoring in Anesthesia and Critical Care Medicine", Casey D. Blitt, Churchill Livingstone, 1985. Electrode 5b is located between electrode 4b and electrode 6.

[0017] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a reflective optical sensor 7 for monitoring substances in tissues, e.g. SpO2 is placed on the face of the patient, anywhere where suitable for the structure of the sensor, eg. but not limited to on the forehead above electrode 6. The optical sensor 7 comprises an emitter and a receiver located close to each other. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector.

[0018] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4a and 6 are the NMT recording electrodes and electrode 5 (a or b) is the NMT grounding electrode. Electrodes 4 (a or b) and 6 also record EEG and EMG signals used e. g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation.

[0019] The embodiment shown in Figure 1 comprises also a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se.

[0020] All electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 as shown in Figure 1. Instead of a single connector 10 a series of connectors may be used as told before.

[0021] The second embodiment is described in Figure 2. The sensor arrangement shown in Figure 2 comprises an array of electrodes for measuring EEG, EMG and NMT. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. If location b is used, electrode 4a is also used. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0022] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b,

and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e. g. SpO2 is placed on the nose of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of the nose. The emitter comprises LEDs of different wavelengths and the receiver comprises of a photodetector.

[0023] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4a and 6 are the NMT recording electrodes and electrode 5 (a or b) is the NMT grounding electrode. Electrodes 4 (a or b) and 6 also record EEG and EMG signals used e. g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. plethysmographic curve, the heartrate and the blood oxygen saturation.

[0024] The embodiment shown in Figure 2 comprises also a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se.

[0025] All electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 as shown in Figure 2. Instead of a single connector 10 a series of connectors may be used as told before.

[0026] The third embodiment is described in Figure 3. The sensor arrangement shown in Figure 3 comprises an array of electrodes for measuring EEG, EMG and NMT. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. If location b is used, electrode 4a is also used. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0027] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e. g. SpO2 is placed on the ear of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of the auricle. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector.

[0028] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4a and 6 are the NMT recording electrodes and electrode 5 (a or b) is the NMT grounding electrode. Electrodes 4 (a or b) and 6 also record EEG and EMG signals used e. g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation.

[0029] The embodiment shown in Figure 3 comprises also a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The base element 9 can be formed and designed freely according to the existing need as shown in the Figures, ie. for example the base element 9 in Figure 3 is slightly different when compared to the base element 9 in Figure 1. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se.

[0030] All electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 as shown in Figure 3. Instead of a single connector 10 a series of connectors may be used as told before.

[0031] The fourth embodiment is described in Figure 4. The sensor arrangement shown in Figure 4 comprises an array of electrodes for measuring EEG, EMG and for NMT stimulus. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0032] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a reflective optical sensor 7 for monitoring substances in tissues, e.g. SpO2 is placed on the face of the patient, anywhere where suitable for the structure of the sensor, eg. but not limited to on the forehead above electrode 6. The optical sensor 7 comprises an emitter and a receiver located close to each other. The emitter comprises LEDs

of different wavelengths and the receiver comprises a photodetector. A mechanical piezoelectric sensor 8 is located over either the procerus, frontalis, corrugator or orbicularismuscle or a combination of these.

[0033] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4 (a or b) and 6 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation. The mechanical piezoelectric sensor 8 records muscle response to NMT stimulus.

[0034] Also the embodiment shown in Figure 4 comprises according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0035] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in Figures 1 - 3. Instead of a single connector 10 a series of connectors may be used as told before.

[0036] The fifth embodiment is described in Figure 5. The sensor arrangement shown in Figure 5 comprises an array of electrodes for measuring EEG, EMG and for NMT stimulus. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0037] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e. g. SpO2 is placed on the nose of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of the nose. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector. A mechanical piezoelectric sensor 8 is located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these.

[0038] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4 (a or b) and 6 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation. The mechanical piezoelectric sensor 8 records muscle response to NMT stimulus.

[0039] Also the embodiment shown in Figure 5 comprises according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0040] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in Figures 1 - 4. Instead of a single connector 10 a series of connectors may be used as told before in connection with the previous embodiments.

[0041] The sixth embodiment is described in Figure 6. The sensor arrangement shown in Figure 6 comprises an array of electrodes for measuring EEG, EMG and for NMT stimulus. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0042] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e. g. SpO2 is placed on the ear of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of either auricle. The emitter comprises LEDs of different wavelengths and the receiver com-

prises a photodetector. A mechanical piezoelectric sensor 8 is located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these.

[0043] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4 (a or b) and 6 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation. The mechanical piezoelectric sensor 8 records muscle response to NMT stimulus.

[0044] Also the embodiment shown in Figure 6 comprises according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0045] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in Figures 1 - 5. Instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 5.

[0046] The seventh embodiment is described in Figure 7. The sensor arrangement shown in Figure 7 comprises an array of electrodes for measuring EEG, EMG and NMT. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. If location b is used, electrode 4a is also used. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0047] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same.

[0048] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4a and 6 are the NMT recording electrodes and electrode 5 (a or b) is the NMT grounding electrode. Electrodes 4 (a or b) and 6 also record EEG and EMG signals used e. g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3.

[0049] Also the embodiment shown in Figure 7 comprises according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0050] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in Figures 1 - 6. Instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 6.

[0051] The eighth embodiment is described in Figure 8. The sensor arrangement shown in Figure 8 comprises an array of electrodes for measuring EEG, EMG and for NMT stimulus. The electrodes are located on the face of the patient. Electrode 1 is located just posterior to the lower part of the pinna and electrode 2 is located just anterior to the tragus. Electrode 3 is located below the eye. Electrodes 4 and 5 have two alternative locations, a and b. Electrode 4a is located on the temple area between the corner of the eye and the hairline. Electrode 5a is located above the eye at the same level as electrode 6, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 4b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 5b is located between electrode 4b and electrode 6.

[0052] It is very advantageous to place electrode 5b essentially in the middle of electrodes 4b and 6 so that the distances between electrode 5b and electrode 4b, and electrode 5b and electrode 6 are essentially the same. A mechanical piezoelectric sensor 8 is located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these.

[0053] Electrodes 1 and 2 are the NMT stimulus electrodes, stimulating the facial nerve. Electrodes 4 (a or b) and 6 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 5 (a or b) is the reference electrode for the EEG and EMG measurements. The EEG and EMG measurement can be enhanced using electrode 3 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 3. The mechanical piezoelectric sensor 8 records muscle response to NMT stimulus.

[0054] Also the embodiment shown in Figure 8 comprises according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0055] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in connection with Figures 1 - 7 instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 7.

[0056] The ninth embodiment is described in Figure 9. The sensor arrangement shown in Figure 9 comprises an array of electrodes for measuring EEG and EMG. The electrodes are located on the face of the patient. Electrode 1 is located below the eye. Electrodes 2 and 3 have two alternative locations, a and b. Electrode 2a is located on the temple area between the corner of the eye and the hairline. Electrode 3a is located above the eye at the same level as electrode 4, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 2b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 3b is located between electrode 2b and electrode 4.

[0057] It is very advantageous to place electrode 3b essentially in the middle of electrodes 2b and 4 so that the distances between electrode 3b and electrode 2b, and electrode 3b and electrode 4 are essentially the same. In addition to these electrodes, a reflective optical sensor 7 for monitoring substances in tissues, e.g. SpO2 is placed on the face of the patient, anywhere where suitable for the structure of the sensor, for example on the forehead as shown in Figure 9. The optical sensor 7 comprises an emitter and a receiver located close to each other. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector.

[0058] Electrodes 2 (a or b) and 4 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 3 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 1 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 1. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation.

[0059] The embodiment shown in Figure 9 comprises also according to the invention a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0060] In this embodiment all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in connection with Figures 1 - 8. Instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 8.

[0061] The tenth embodiment is described in Figure 10. The sensor arrangement shown in Figure 10 comprises an array of electrodes for measuring EEG and EMG. The electrodes are located on the face of the patient. Electrode 1 is located below the eye. Electrodes 2 and 3 have two alternative locations, a and b. Electrode 2a is located on the temple area between the corner of the eye and the hairline. Electrode 3a is located above the eye at the same level as electrode 4, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 2b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 3b is located between electrode 2b and electrode 4.

[0062] It is very advantageous to place electrode 3b essentially in the middle of electrodes 2b and 4 so that the distances between electrode 3b and electrode 2b, and electrode 3b and electrode 4 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e.g. SpO2 is placed on the nose of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of the nose. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector.

[0063] Electrodes 2 (a or b) and 4 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 3 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 1 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 1. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation.

[0064] As told in connection with the previous embodiments also the embodiment shown in Figure 10 comprises a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0065] In the embodiment of Figure 10 all electrodes and sensors described above are connected to a single

connector 10 attached to the base element 9 in the same way as described in connection with Figures 1 - 9. Instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 9.

[0066] The eleventh embodiment is described in Figure 11. The sensor arrangement shown in Figure 11 comprises an array of electrodes for measuring EEG and EMG. The electrodes are located on the face of the patient. Electrode 1 is located below the eye. Electrodes 2 and 3 have two alternative locations, a and b. Electrode 2a is located on the temple area between the corner of the eye and the hairline. Electrode 3a is located above the eye at the same level as electrode 4, which is located between the eyebrows of the patient at the center of the forehead, approximately 4 cm above the nose. Electrode 2b is located at either location F3 or F4 (left or right side) of the International 10-20 system. Electrode 3b is located between electrode 2b and electrode 4.

[0067] It is very advantageous to place electrode 3b essentially in the middle of electrodes 2b and 4 so that the distances between electrode 3b and electrode 2b, and electrode 3b and electrode 4 are essentially the same. In addition to these electrodes, a transmission optical sensor 7 for monitoring substances in tissues, e. g. SpO2 is placed on the ear of the patient. The optical sensor 7 comprises an emitter and a receiver located on opposite sides of either auricle. The emitter comprises LEDs of different wavelengths and the receiver comprises a photodetector.

[0068] Electrodes 2 (a or b) and 4 record EEG and EMG signals used e.g. to derive the Entropy parameter. Electrode 3 (a or b) is the reference electrode for the EEG and EMG measurement. The EEG and EMG measurement can be enhanced using electrode 1 e.g. but not limited to record eye movements. The EEG and EMG measurement can be done with or without electrode 1. The optical sensor measures e.g. the plethysmographic curve, the heartrate and the blood oxygen saturation.

[0069] As told in connection with the previous embodiments also the embodiment shown in Figure 11 comprises a base element 9. The base element 9 can be made of any appropriate flexible material, for example of plastic material. The electrodes and sensors described above can be attached to the base element by using any appropriate method known per se. As told before the form and the structure of the base element can be designed quite freely according to the existing need.

[0070] In the embodiment of Figure 11 all electrodes and sensors described above are connected to a single connector 10 attached to the base element 9 in the same way as described in connection with Figures 1 - 10. Instead of a single connector 10 a series of connectors may be used as told before in connection with the embodiments shown in Figures 1 - 10.

[0071] In the embodiments shown in Figures 1 - 11 all electrodes and sensors are connected to a single connector 10 for connecting the sensor arrangement to a patient monitor. Said arrangement reduces the amount of cables needed between the patient and the patient monitor. As told above depending on the sensor design it might however be necessary to use separate connectors for some of the parameters, ie. for some of the electrodes used, to meet patient leakage current and isolation requirements. Said separate connectors can be arranged as a compact unit, in which the connectors are placed side by side for example.

[0072] The above embodiments of the invention are by no means intended to limit the invention, but the invention can be modified quite freely within the scope of the claims. Accordingly, it is clear that an embodiment of the invention or its details do not necessarily need to be just as described in the figures, but solutions of other kinds are also possible.

Claims

1. Sensor arrangement for measuring anesthesia parameters from the head of a patient the sensor arrangement comprising a base element (9) and an array of electrodes and an optical sensor (7) for monitoring substances in tissues, **characterized in that** all electrodes and sensors (1-8) are connected to a single connector (10) or a series of connectors attached to the base element (9) for connecting the sensor arrangement to a patient monitor.

2. The arrangement of claim 1, **charactrized in that** the first and the second electrode (1,2) of the array of electrodes are NMT stimulus electrodes located just posterior to the lower part of the pinna and just anterior to the tragus to stimulate the facial nerve.

3. The arrangement of claim 1 or 2, **characterized in that** three of the electrodes (4a,5a,6;2a,3a,4) of the array of electrodes are used to measure EEG and EMG, the first (4a;2a) of the three electrodes being located on the temple area between the corner of the eye and the hairline, the second electrode (5a; 3a) of the three electrodes being located above the eye at the same level as the third electrode (6;4) of the three electrodes which is located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3;1) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

4. The arrangement of claim 3, **characterized in that** the electrodes (4a, 6) are used to measure NMT response.

5. The arrangement of claim 1 or 2, **characterized in**

that three of the electrodes (4b,6,3;2b,4,1) of the array are used to measure EEG and EMG, the first (4b;2b) of the three electrodes being located on location F2 or F4 of the International 10-20 system, the second electrode (6;4) of the three electrodes being located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3;1) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

6. The arrangement of claim 5, **characterized in that** there is an additional electrode (4a) located on the temple area between the corner of the eye, and the additional electrode (4a) and the second (6) and the third electrodes (3) of the three electrodes are used to measure NMT response.

7. The arrangement of claim 1,2, 3, 4, 5 or 6, **characterized in that** the optical sensor (7) for monitoring substances in tissues is attached to the forehead.

8. The arrangement of claim 1, 2, 3, 4, 5 or 6, **characterized in that** the optical sensor (7) for monitoring substances in tissues is attached to the root of the nose.

9. The arrangement of claim 1, 2, 3, 4, 5 or 6, **characterized in that** the optical sensor (7) for monitoring substances in tissues is attached to the ear.

10. The arrangement of claim 1, **characterized in that** the optical sensor (7) for monitoring substances in tissues is a SpO2 sensor.

11. Sensor arrangement for measuring anesthesia parameters from the head of a patient the sensor arrangement comprising a base element (9) and an array of electrodes and an optical sensor (7) for monitoring substances in tissues and a mechanical NMT sensor (8), **characterized in that** all electrodes and sensors (1-8) are connected to a single connector (10) or a series of connectors attached to the base element (9) for connecting the sensor arrangement to a patient monitor.

12. The arrangement of claim 11, **characterized in that** the first and the second electrode (1,2) of the array of electrodes are NMT stimulus electrodes located just posterior to the lower part of the pinna and just anterior to the tragus to stimulate the facial nerve.

13. The arrangement of claim 11 or 12, **characterized in that** three of the electrodes (4a,5a,6) of the array of electrodes are used to measure EEG and EMG, the first (4a) of the three electrodes being located on the temple area between the corner of the eye and the hairline, the second electrode (5a) of the three electrodes being located above the eye at the same level as the third electrode (6) of the three electrodes which is located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

14. The arrangement of claim 13, **characterized in that** the mechanical NMT sensor (8) is a piezoelectric sensor located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these to record the response to the NMT stimulus.

15. The arrangement of claim 11 or 12, **characterized in that** three of the electrodes (4b,6,3) of the array are used to measure EEG and EMG, the first (4b) of the three electrodes being located on location F2 or F4 of the International 10-20 system, the second electrode (6) of the three electrodes being located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

16. The arrangement of claim 15, **characterized in that** the mechanical NMT sensor (8) is a mechanical piezoelectric sensor located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these to record the response to the NMT stimulus.

17. The arrangement of claim 11, 12, 13, 14, 15 or 16, characte rized in that the optical sensor (7) for monitoring substances in tissues is attached to the forehead.

18. The arrangement of claim 11, 12, 13, 14, 15 or 16, characte rized in that the optical sensor (7) for monitoring the substances in tissues is attached to the root of the nose.

19. The arrangement of claim 11, 12, 13, 14, 15 or 16, characte rized in that the optical sensor (7) for monitoring substances in tissues is attached to the ear.

20. The arrangement of claim 11, **characterized in that** the optical sensor (7) for monitoring substances in tissues is a SpO2 sensor.

21. Sensor arrangement for measuring anesthesia parameters from the head of a patient the sensor arrangement comprising a base element (9) and an array of electrodes for measuring EEG, EMG and NMT, **characterized in that** sensor arrangement all electrodes and sensors (1-8) are connected to a

single connector (10) or a series of connectors attached to the base element (9) for connecting the sensor arrangement to a patient monitor.

22. The arrangement of claim 21, **characterized in that** the first and the second electrode (1,2) of the array of electrodes are NMT stimulus electrodes located just posterior to the lower part of the pinna and just anterior to the tragus to stimulate the facial nerve.

23. The arrangement of claim 21 or 22, **characterized in that** three of the electrodes (4a,5a,6) of the array of electrodes are used to measure EEG and EMG, the first (4a) of the three electrodes being located on the temple area between the corner of the eye and the hairline, the second electrode (5a) of the three electrodes being located above the eye at the same level as the third electrode (6) of the three electrodes which is located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

24. The arrangement of claim 23, **characterized in that** the electrodes (4a,6) are used to measure NMT response.

25. The arrangement of claim 21 and 22, **characterized in that** three of the electrodes (4b,6,3) of the array are used to measure EEG and EMG, the first (4b) of the three electrodes being located on location F2 or F4 of the International 10-20 system, the second electrode (6) of the three electrodes being located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

26. The arrangement of claim 25, **characterized in that** there is an additional electrode (4a) located on the temple area between the corner of the eye, and the additional electrode (4a) and the second (6) and the third (3) electrodes of the three electrodes are used to measure NMT response.

27. Sensor arrangement for measuring anesthesia parameters from the head of a patient the sensor arrangement comprising a base element (9) and an array of electrodes and a mechanical NMT sensor (8), **characterized in that** all electrodes and sensors (1-8) are connected to a single connector (10) or a series of connectors attached to the base element (9) for connecting the sensor arrangement to a patient monitor.

28. The arrangement of claim 27, **characterized in that** the first and the second electrode (1,2) of the array of electrodes are NMT stimulus electrodes located just posterior to the lower part of the pinna and just anterior to the tragus to stimulate the facial nerve.

29. The arrangement of claim 27 or 28, **characterized in that** three of the electrodes (4a,5a,6) of the array of electrodes are used to measure EEG and EMG, the first (4a) of the three electrodes being located on the temple area between the corner of the eye and the hairline, the second electrode (5a) of the three electrodes being located above the eye at the same level as the third electrode (6) of the three electrodes which is located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

30. The arrangement of claim 29, **characterized in that** the mechanical NMT sensor (8) is a piezoelectric sensor located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these to record the response to the NMT stimulus.

31. The arrangement of claim 27 or 28, **characterized in that** three of the electrodes (4b,6,3) of the array are used to measure EEG and EMG, the first (4b) of the three electrodes being located on location F2 or F4 of the International 10-20 system, the second electrode (6) of the three electrodes being located between the eyebrows of the patient at the center of the forehead, about 4 cm above the nose, and the fourth electrode (3) of the array of electrodes is located below the eye for enhancing the EEG and EMG measurement.

32. The arrangement of claim 21, **characterized in that** the mechanical NMT sensor (8) is a piezoelectric sensor located over either the procerus, frontalis, corrugator or orbicularis muscle or a combination of these to record the response to the NMT stimulus.

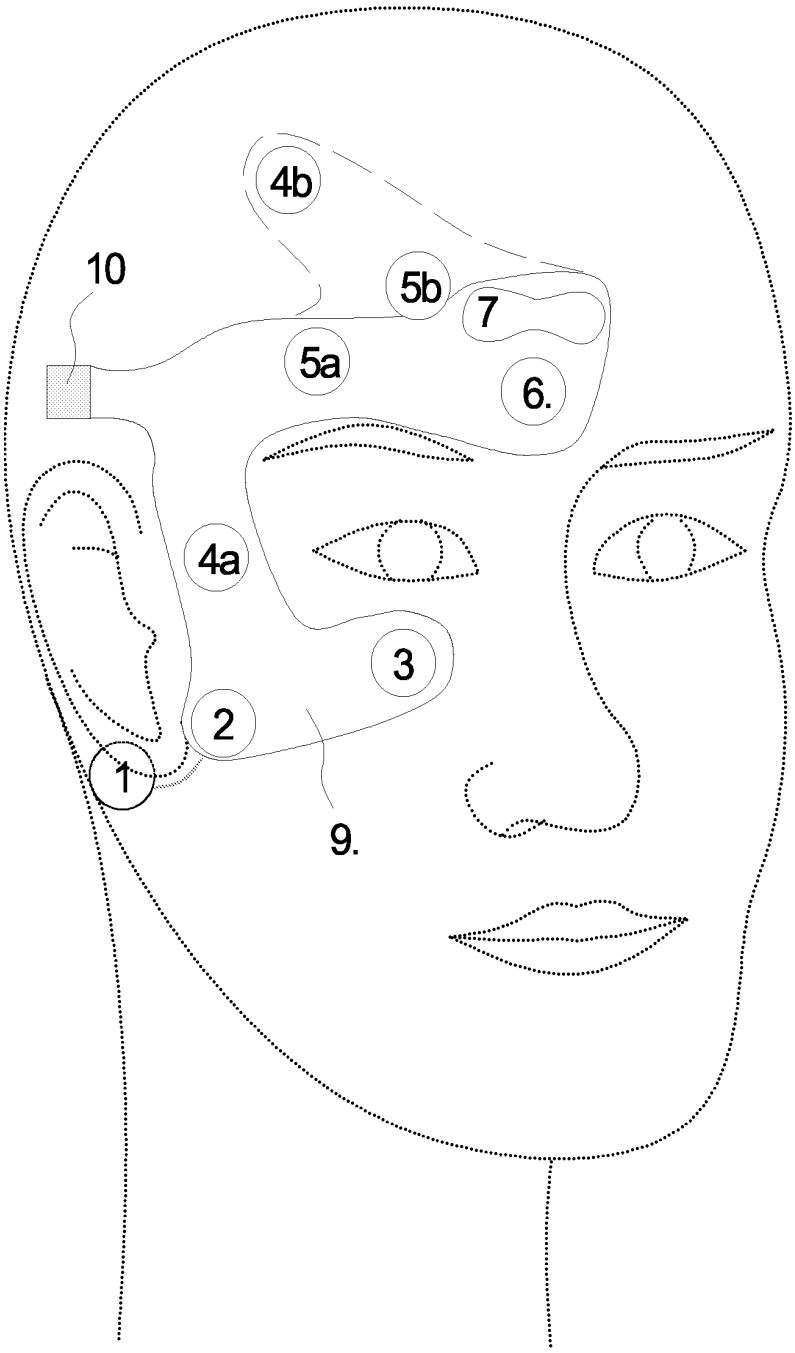

Figure 1. The first embodiment.

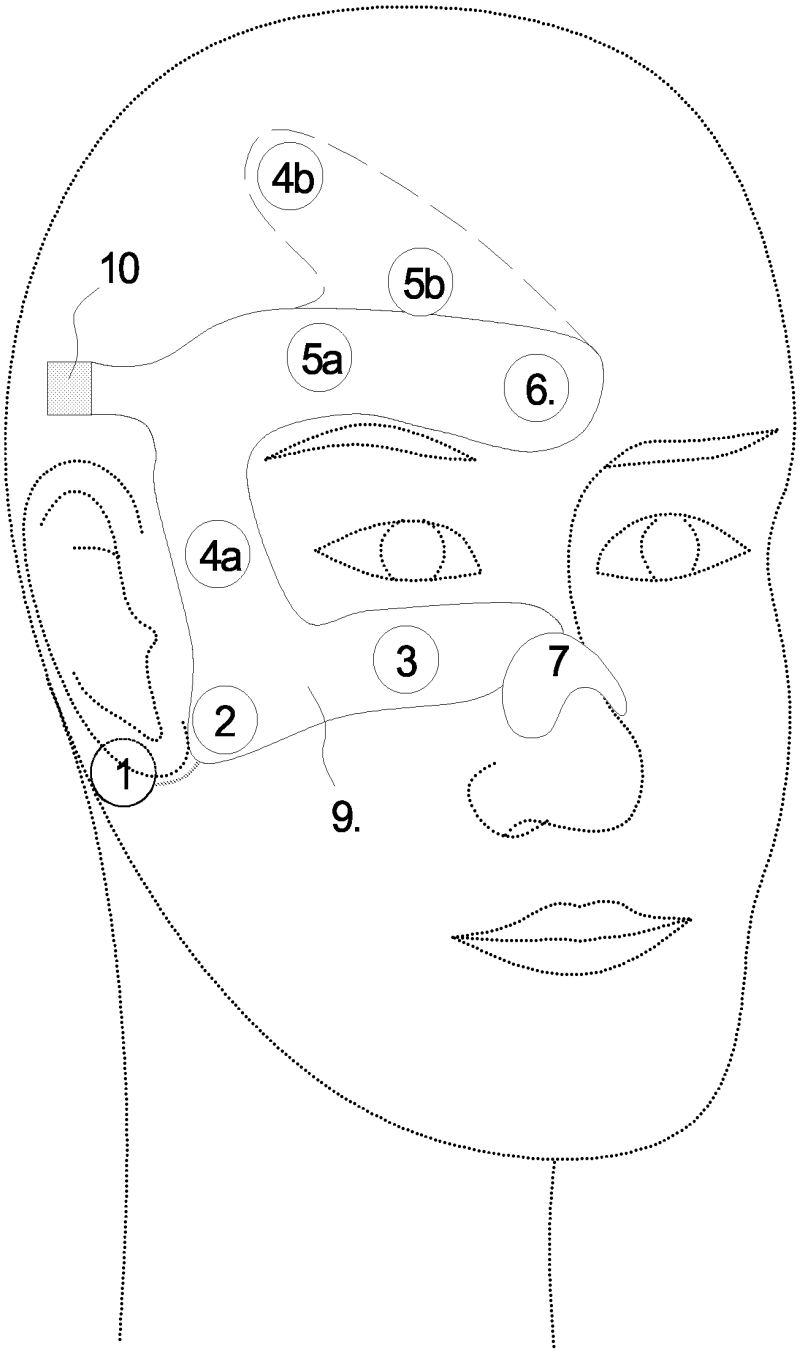

Figure 2. The second embodiment.

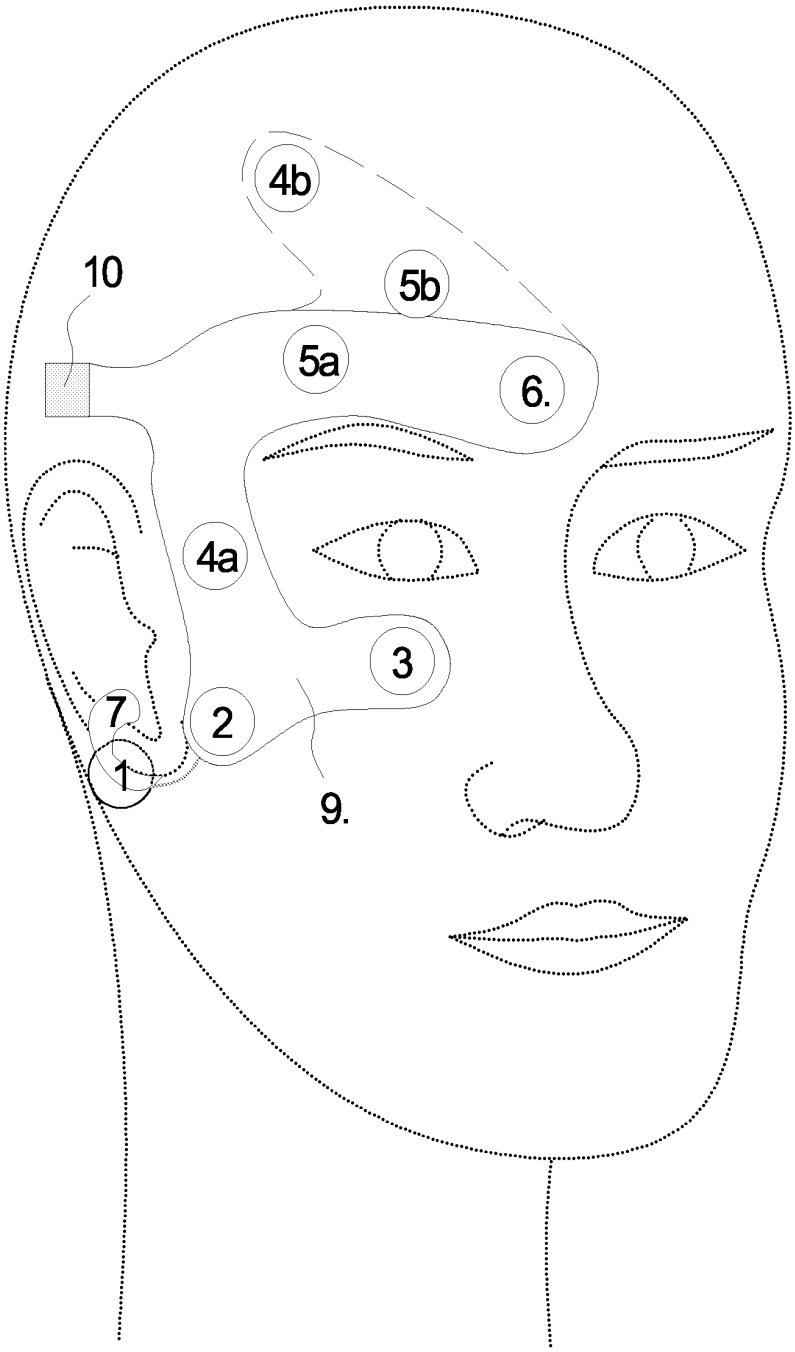

Figure 3. The third embodiment.

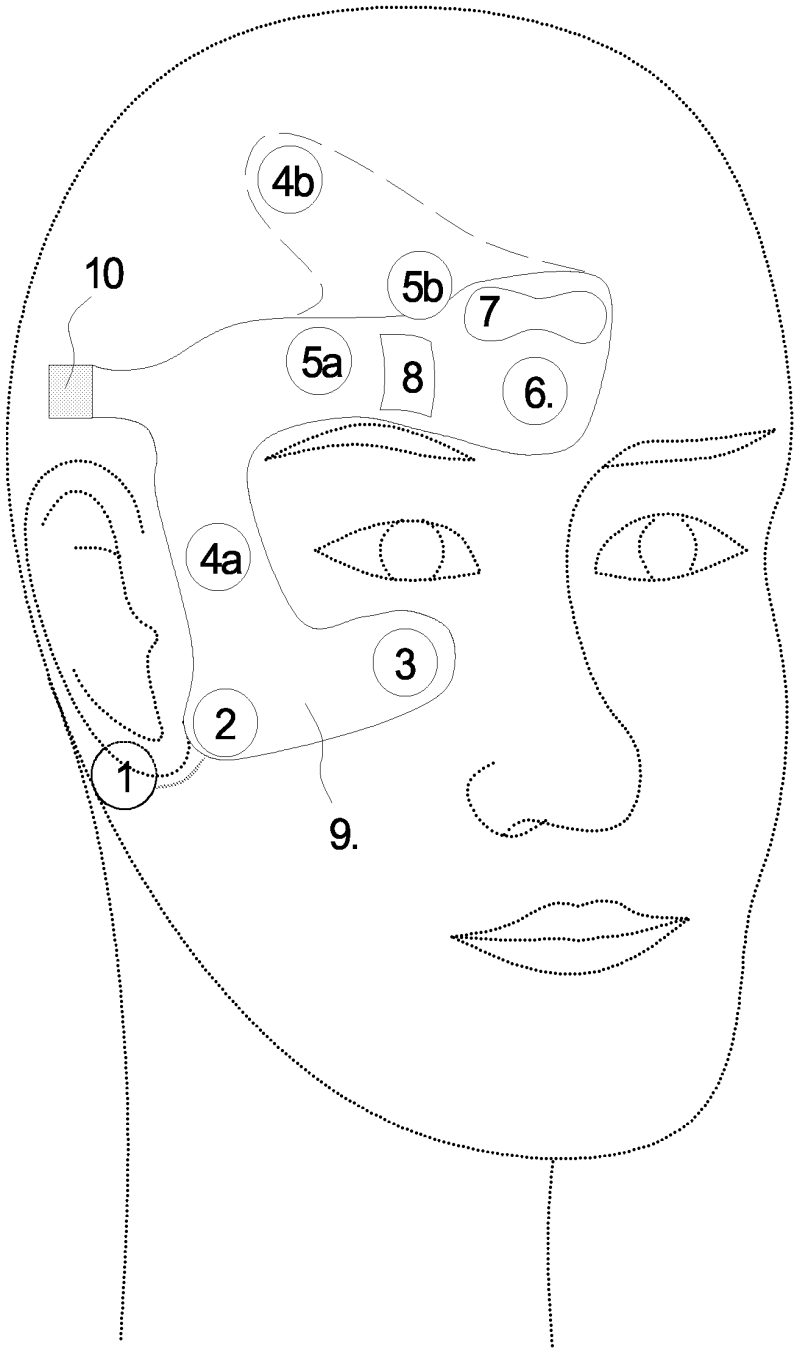

Figure 4. The fourth embodiment.

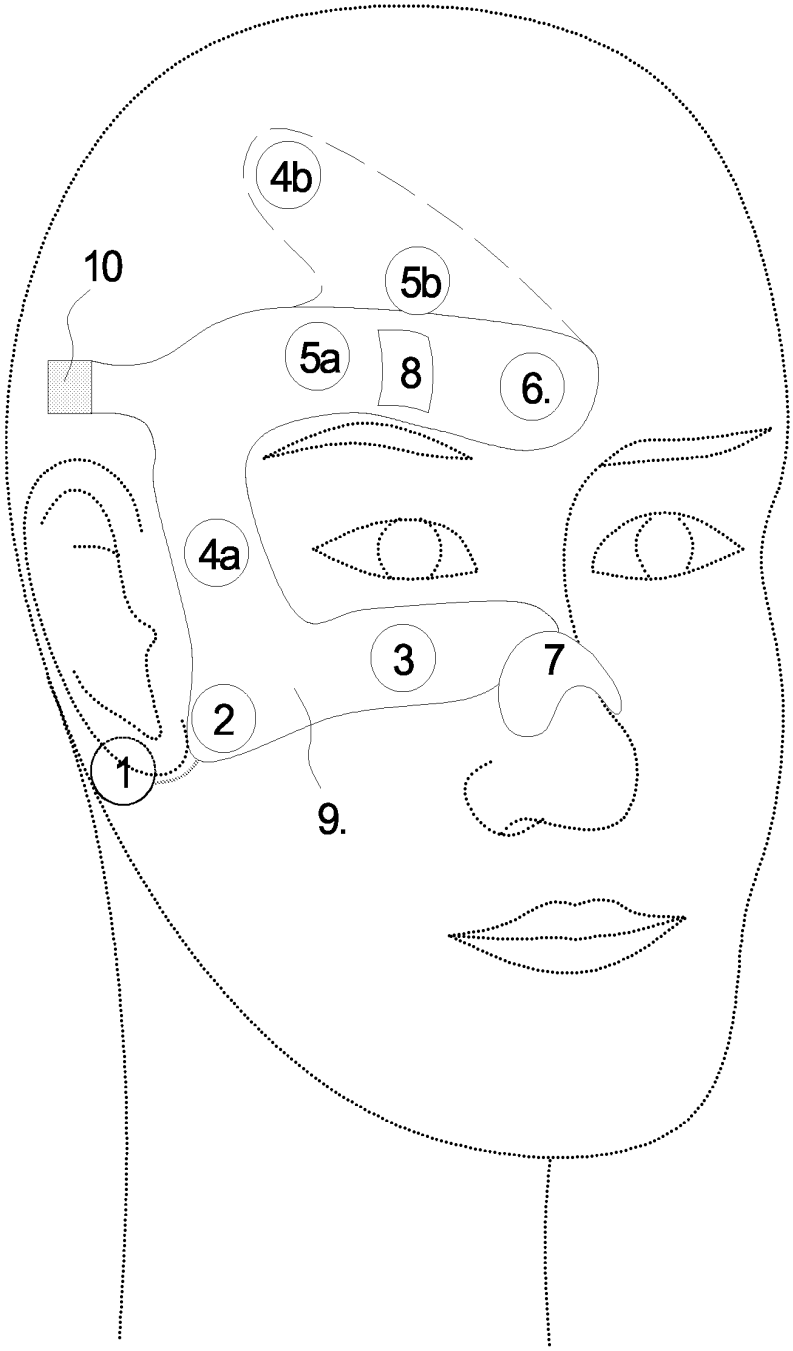

Figure 5. The fifth embodiment.

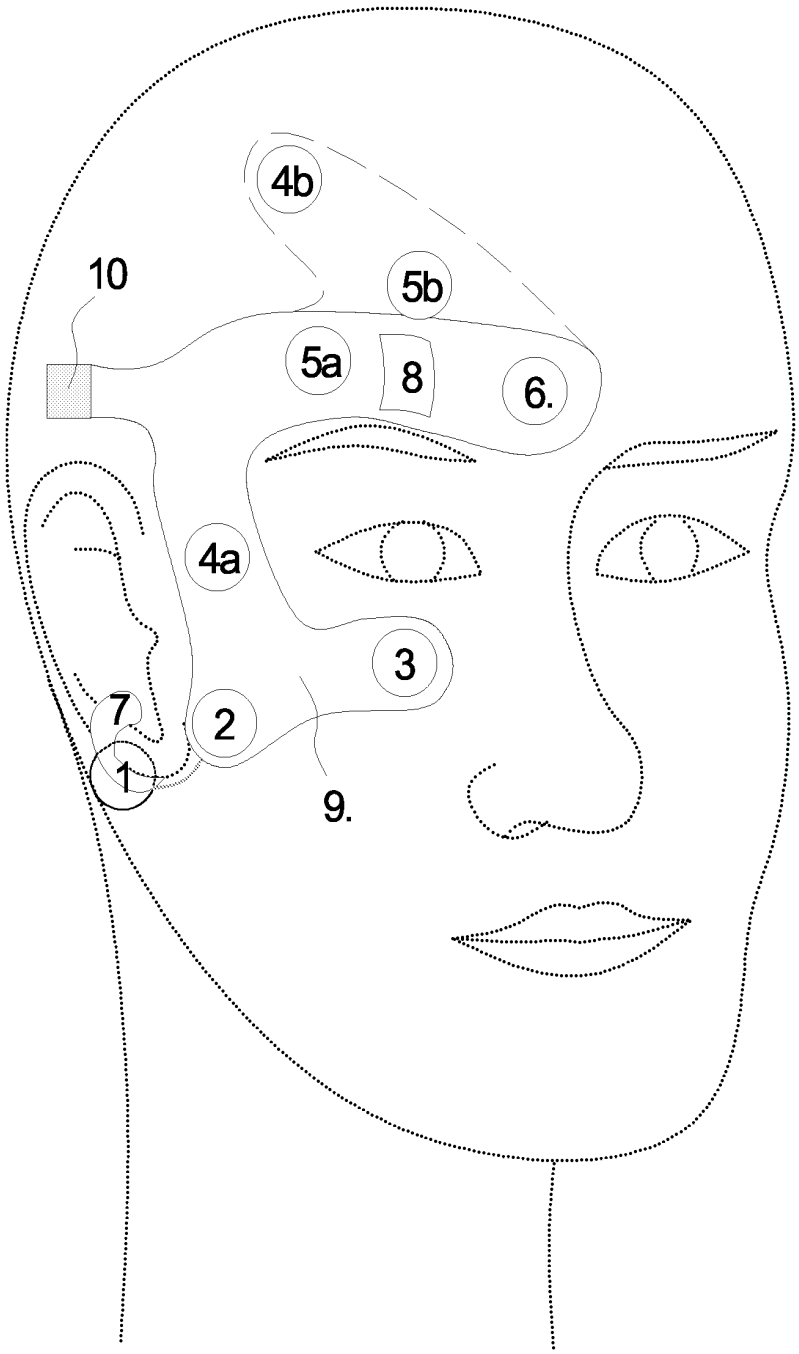

Figure 6. The sixth embodiment.

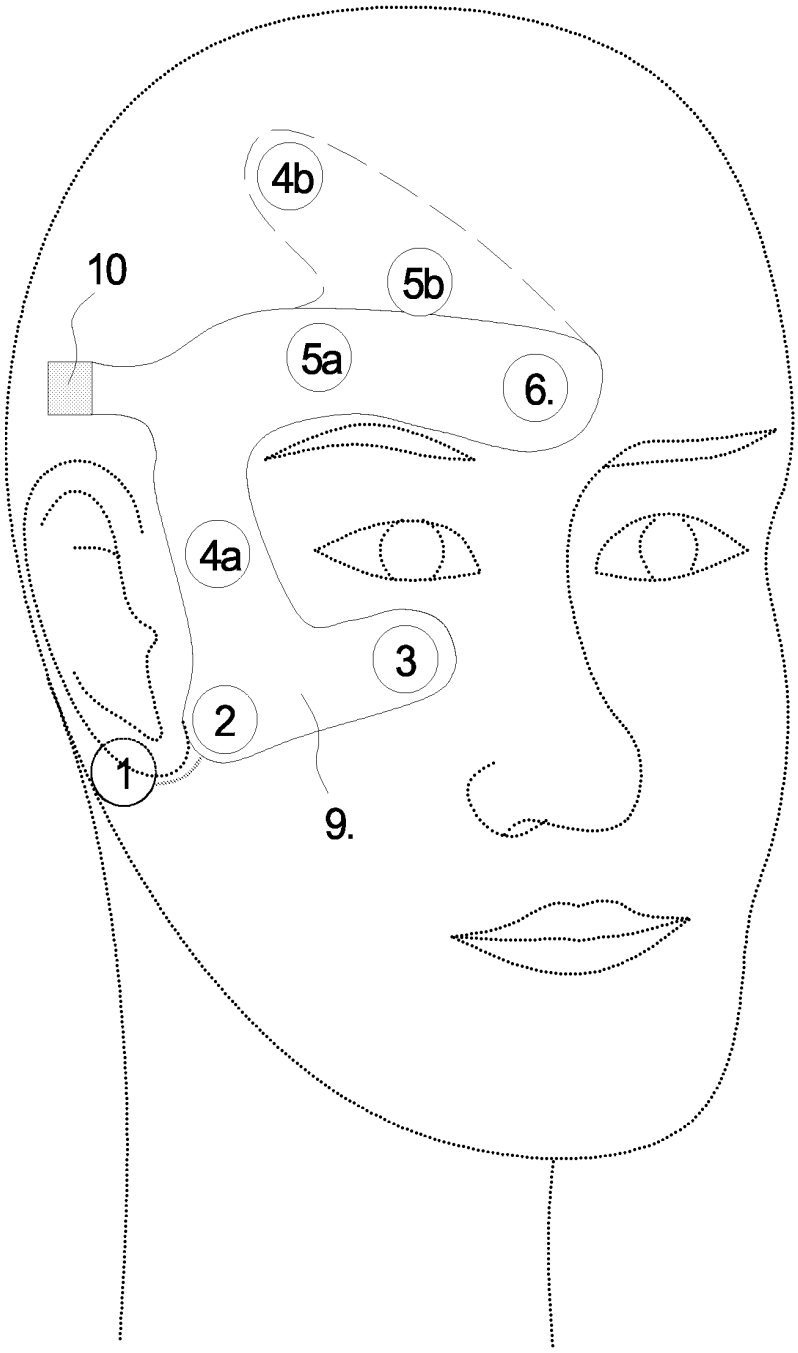

Figure 7. The seventh embodiment.

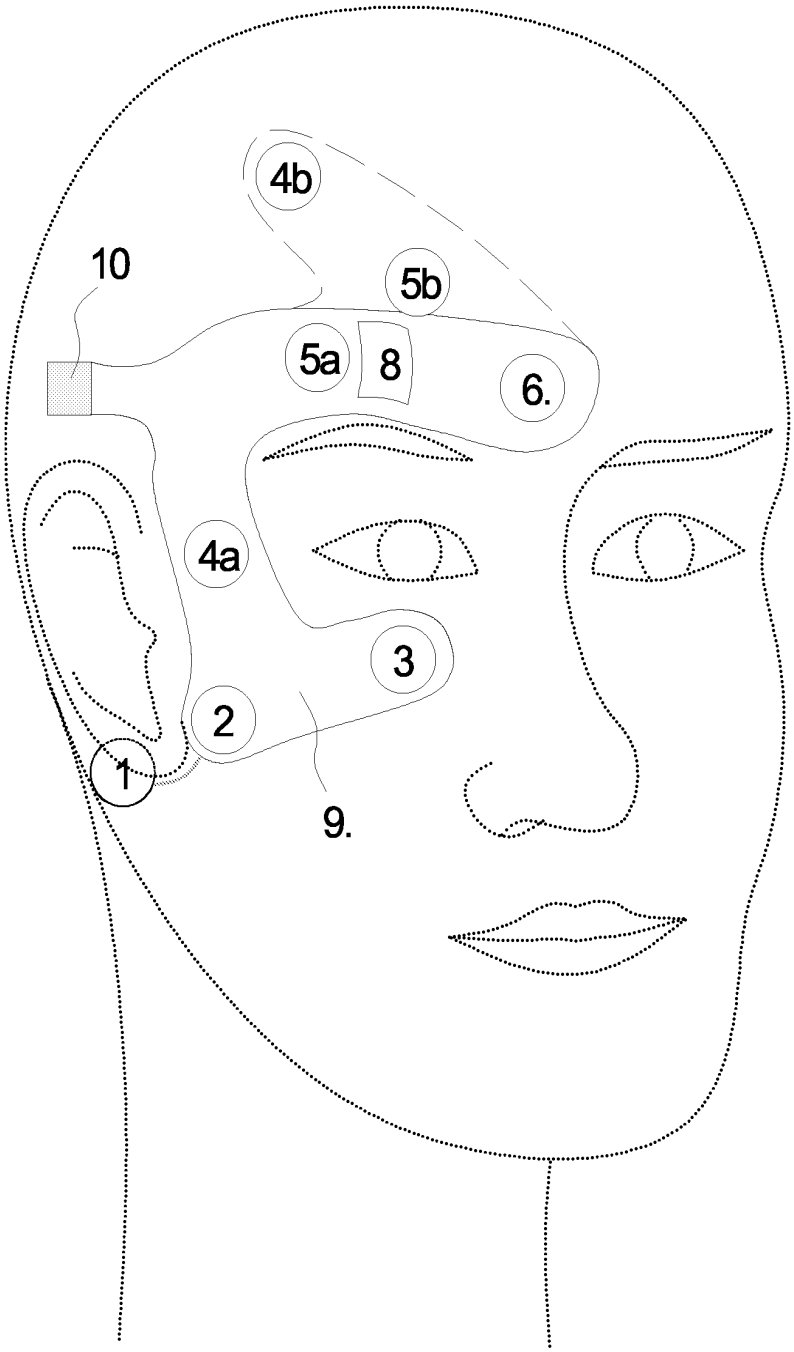

Figure 8. The eighth embodiment.

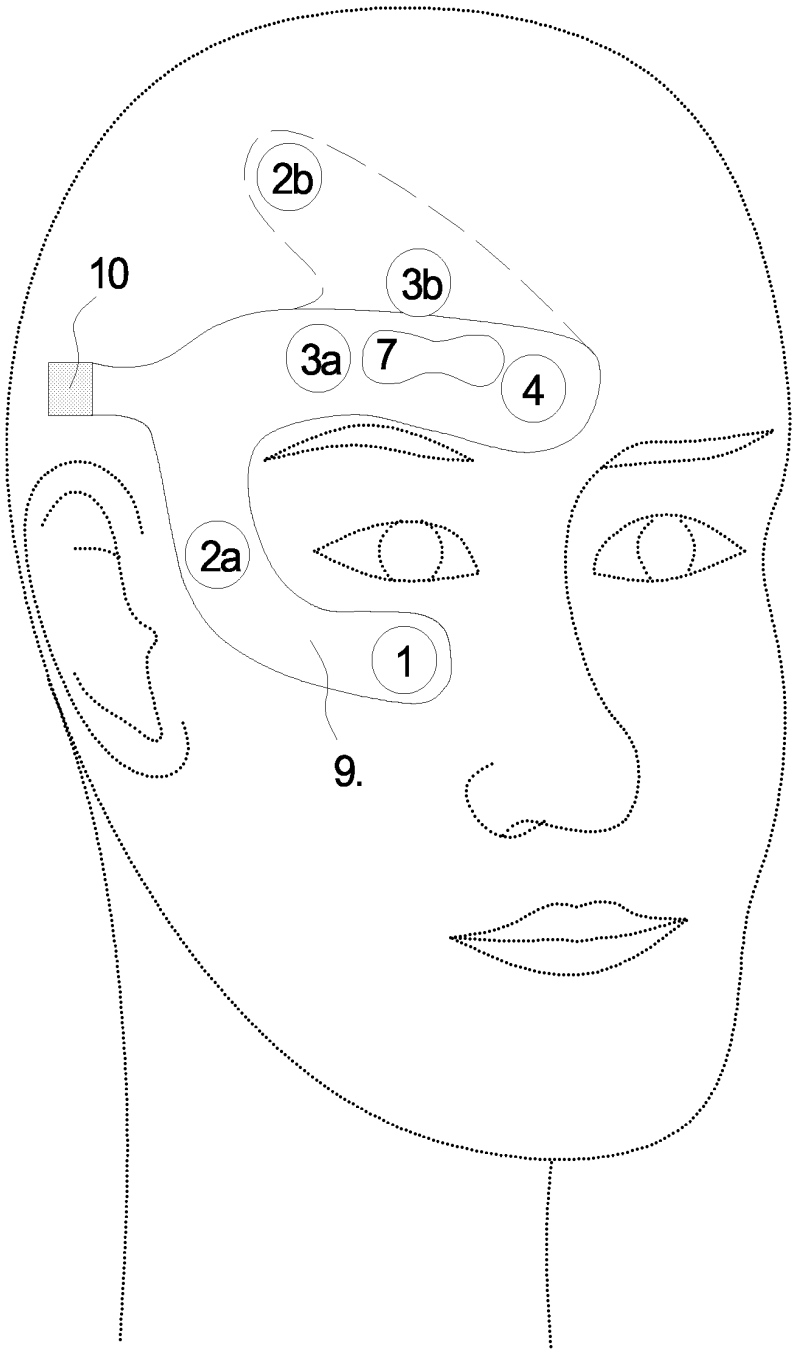

Figure 9. The ninth embodiment.

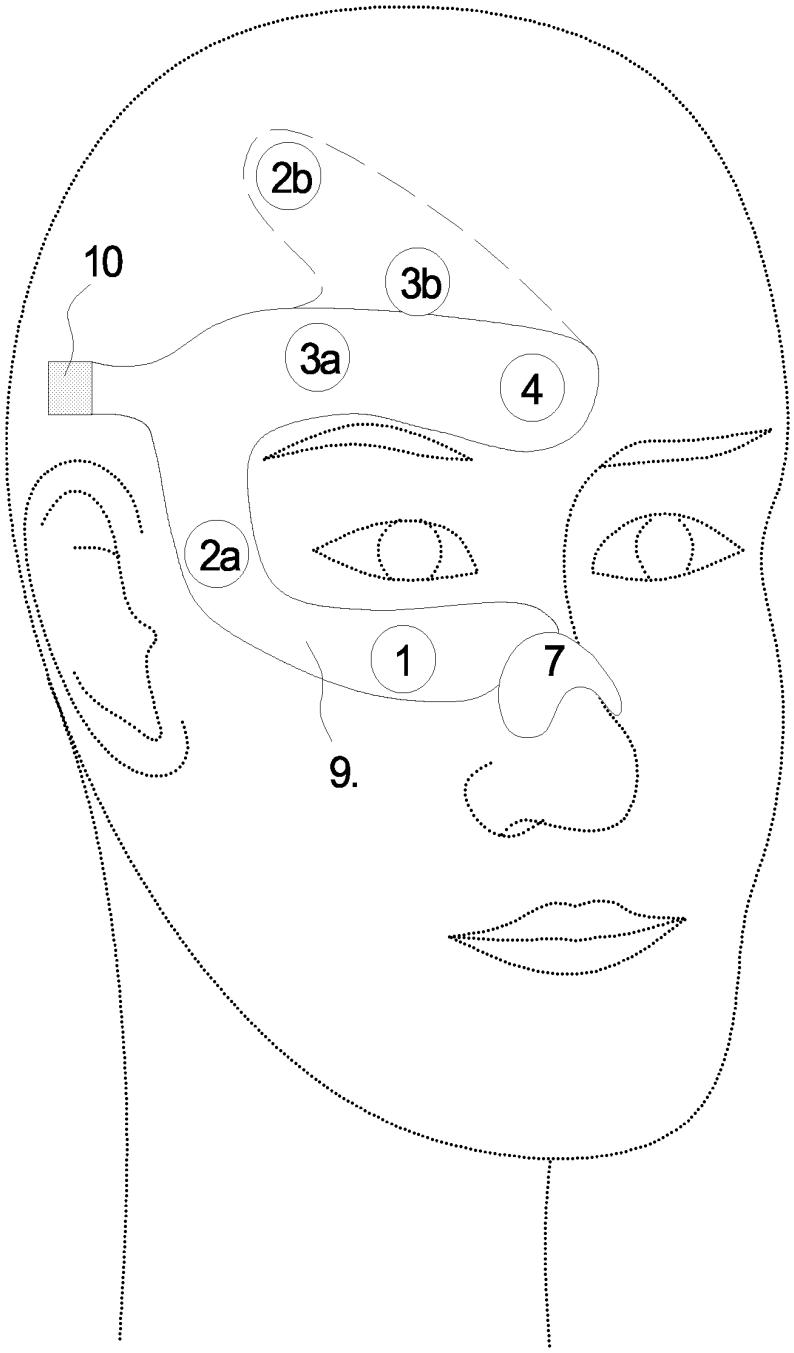

Figure 10. The tenth embodiment.

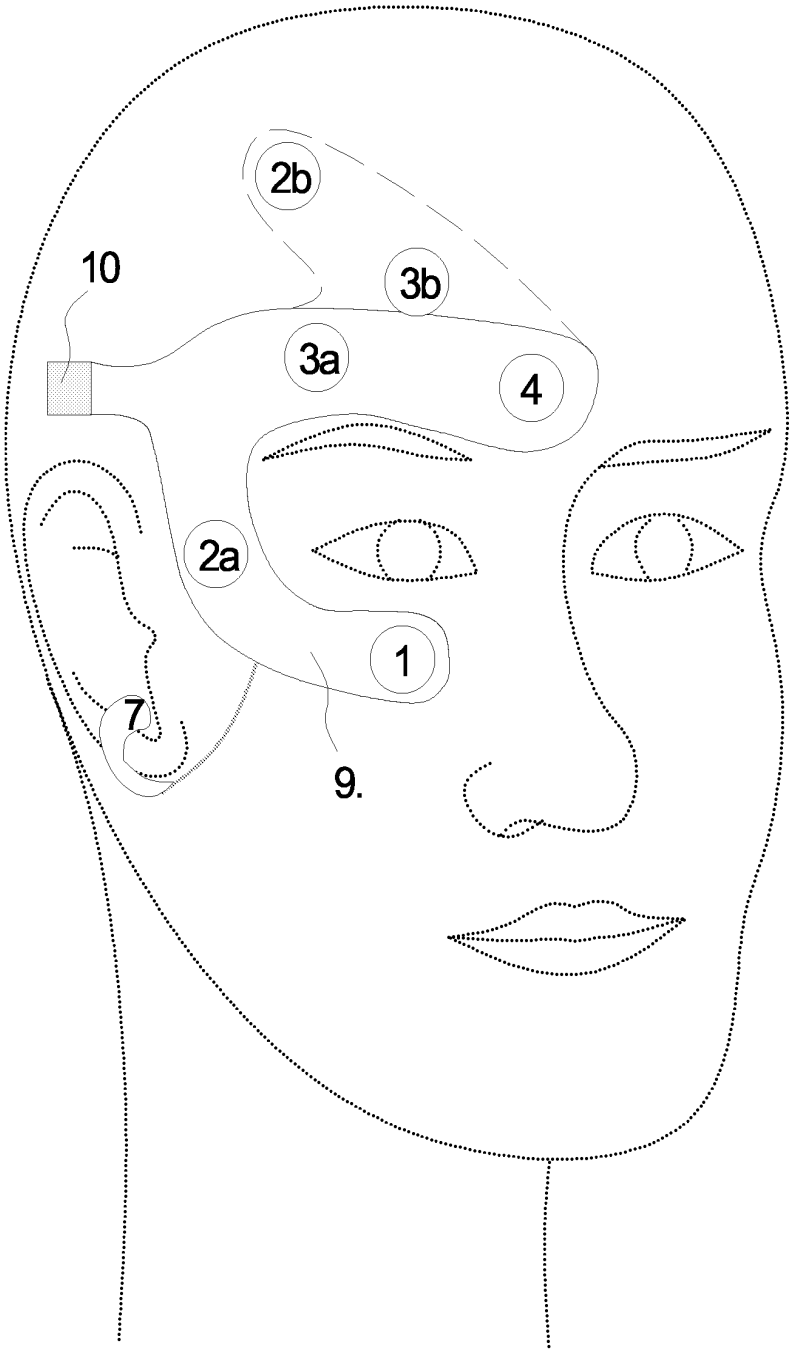

Figure 11. The eleventh embodiment.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 10 4961

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	WO 03/057030 A (MASIMO CORP) 17 July 2003 (2003-07-17) * page 3, line 20 - page 5, line 10; claim 1; figure 1 *	1,7,27 11	A61B5/04 A61B5/05 A61B5/0205
Y	US 4 595 018 A (RANTALA BOERJE) 17 June 1986 (1986-06-17) * column 2, line 37 - line 52; claim 1 *	11	
A	US 2003/009096 A1 (LAHTEENMAKI MARKKU) 9 January 2003 (2003-01-09) * paragraphs [0021] - [0026]; claim 1 *	1-32	
A	US 4 595 013 A (CALLAHAN ALFRED S ET AL) 17 June 1986 (1986-06-17) * claim 1 *	1-32	
A	US 6 394 953 B1 (MCDANIEL TERRIE L ET AL) 28 May 2002 (2002-05-28) * the whole document *	1-32	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

A61B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 December 2004	Chopinaud, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 10 4961

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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09-12-2004

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		US 2003225323 A1	04-12-2003
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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	传感器布置		
公开(公告)号	EP1523934A1	公开(公告)日	2005-04-20
申请号	EP2004104961	申请日	2004-10-11
申请(专利权)人(译)	INSTRUMENTARIUM CORPORATION		
当前申请(专利权)人(译)	GE HEALTHCARE芬兰OY		
[标]发明人	HOSKONEN TERHO KAMPPARI LASSE KYMALAINEN MINNA KALL MAGNUS PESU LEENA		
发明人	HOSKONEN, TERHO KAMPPARI, LASSE KYMÄLÄINEN, MINNA KALL, MAGNUS PESU, LEENA		
IPC分类号	A61B5/00 A61B5/04 A61B5/0402 A61B5/0488 A61B5/11 A61B5/05 A61B5/0205		
CPC分类号	A61B5/6841 A61B5/0059 A61B5/04001 A61B5/0402 A61B5/0488 A61B5/1106 A61B5/4821 A61B5/6814		
优先权	10/688863 2003-10-17 US		
其他公开文献	EP1523934B1		
外部链接	Espacenet		

摘要(译)

用于测量来自患者头部的麻醉参数的传感器装置，传感器装置包括基座元件（9）和电极阵列以及用于监测组织中物质的光学传感器（7）。在传感器布置中，所有电极和传感器连接到单个连接器（10）或连接到基座元件（9）的一系列连接器，用于将传感器装置连接到患者监视器。

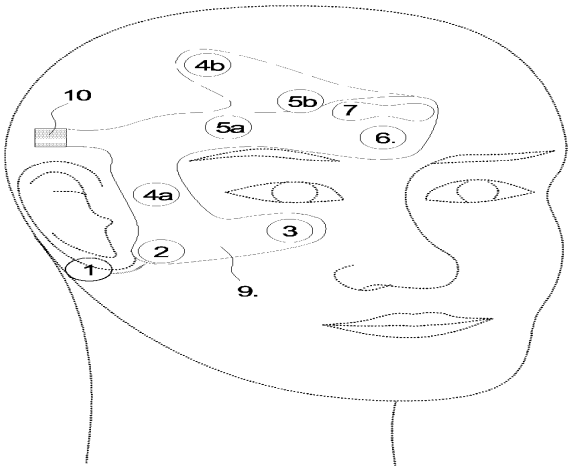

Figure 1. The first embodiment.