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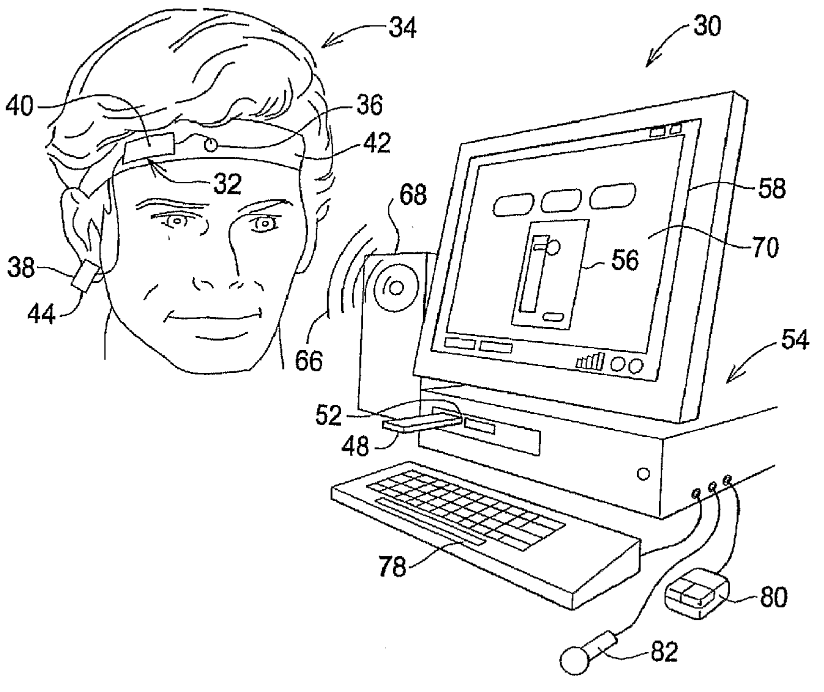
(54) **Title:** A DEVICE AND METHOD FOR SENSING ELECTRICAL ACTIVITY IN TISSUE



(57) **Abstract:** An exemplary embodiment providing one or more improvements includes apparatus and methods for sensing electrical activity in tissue of a person in a manner which substantially limits or eliminates interference from noise in a surrounding environment.

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A DEVICE AND METHOD FOR SENSING ELECTRICAL ACTIVITY IN TISSUE

RELATED APPLICATIONS

¶1 The present application claims priority from U.S. Provisional Application Ser. No. 60/713,899, filed on September 2, 2005 which is incorporated herein by reference and attached hereto as Exhibit A. In addition, U.S. Patent Application Serial No. XX (Attorney Docket No. CAM-2) titled A Device and Method for Determining and Improving Present Time Emotional State of a Person which was invented by Ray Caamaño et al. and which has the same filing date as the present application, is hereby incorporated by reference.

BACKGROUND

¶2 Devices used for sensing electrical activity in tissue have many uses in modern society. In particular modern electroencephalograms (EEGs) are used for measuring electrical activity in the brains of people for anesthesia monitoring, attention deficit disorder treatment, epilepsy prediction, and sleep monitoring, among other uses. Unfortunately, the complexity and cost of prior modern EEGs typically limits their use to clinics or other facilities where the device can be used on numerous people under the expert attention of a trained medical professional. Using the EEG on numerous people in a clinical setting helps to distribute the cost of the machine to the people which use it. EEGs can cost several thousand dollars.

¶3 Trained personnel are used for setting up and operating EEGs because of the complexities involved. Setting up prior EEGs involves preparing the skin of the person for connection of electrodes. The skin is typically prepared by shaving the hair from the area, sanding the skin to remove the outer surface and applying a conductive gel or liquid to the skin before attaching the electrode to the skin. Such extensive skin preparation is needed because contact resistance between the electrode and the skin must be reduced in order for prior EEGs to work properly. Contact resistance in these prior EEGs typically needs to be 20k ohms or less.

¶4 Typical prior EEGs are subject to errors caused by electrical and magnetic noise from the environment surrounding the person. Errors are also caused by slight variations in internal components of the EEG and other sources, such as movement of the person during the operation of the EEG. Environmental noise can be caused by 60 Hz power in electrical wiring and lights in the area where the EEG is used, and other sources. Even the friction of any object moving through the air can cause noise from static electricity. Most or all prior EEGs have two electrodes are connected to the person's head and wires which are run from each of the electrodes to the EEG machine. The routing of the wires and the positions of the noise causing elements in the environment can cause significant errors in the measurements done by the EEG.

¶5 Measuring the electrical activity in the brain is difficult because the electrical signal being measured is many times smaller than the noise in the system. In many instances, the noise is on the order of a few volts or a few tens of volts while the electrical signal being measured is only in the microvolt range. This gives a signal-to-noise ratio of 10^-6.

¶6 Prior EEGs have used very precise differential amplifiers, such as instrumentation amplifiers, to measure the electrical signal. The amplifier is referenced to a common reference such as the leg of the user. Each of the two wires from the two electrodes on the person's head are connected to the inputs of the differential amplifier. The output of the differential amplifier is a voltage relative to the reference which is proportional to the difference in voltage between the two electrodes times a constant. The measurement in this case is very sensitive because the differential amplifier is finding a small difference, the brain signal, between two signals which are 10^6 times as large. These are reasons why small variations in components, the routing of the wires and other factors cause significant errors in the measurement and why prior EEGs are expensive and hard to use.

¶7 Another problem with the prior EEGs is that the 60 Hz noise is amplified at the first stage which saturates the signals before they are subtracted. In prior EEGs, designers go to great lengths to design systems that balance or shield the noise to avoid saturation. Systems which use the principle of subtracting two large numbers in measuring a small number are prone to these kinds of problems.

¶8 The foregoing examples of the related art and limitations related therewith are intended to be illustrative and not exclusive. Other limitations of the related art will become apparent to those of skill in the art upon reading of the specification and a study of the drawings.

SUMMARY

¶9 The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods which are meant to be exemplary and illustrative, not limiting in scope. In various embodiments, one or more of the above-described problems have been reduced or eliminated, while other embodiments are directed to other improvements.

¶10 A method is described for sensing electrical activity in tissue of a user. Electrical activity is detected from the tissue between a first point and a second point on skin of the user and a voltage signal is generated in response thereto which contains a signal of interest and undesired signals. The voltage signal is amplified to amplify the signal of interest and undesired signals without substantially amplifying the noise. The amplification results in an output signal.

¶11 Another method is disclosed for sensing electrical activity in tissue of a user in a noise environment that is subjected to electrical noise. A sensor electrode is connected to skin of the user at a first point. A reference electrode is connected to skin of the user at a second point which is in a spaced apart relationship to the first point to allow the sensor electrode to sense the electrical activity in the tissue at the first point relative to the second point. An amplifier is provided which is configured to amplify the electrical activity while substantially reducing the influence from the noise environment.

¶12 A sensor circuit is described for sensing electrical activity in tissue of a user and isolating and amplifying a signal of interest from the sensed electrical activity. The sensor circuit includes a sensor electrode for placing on skin of the user at a first point. A reference electrode for placing at a second point which is a distance away from the first point to allow the sensor electrode to sense the electrical activity and to produce a voltage signal relative to the second point which includes the signal of interest in response. An electronic module of the sensor circuit includes a power source with positive and negative source voltages and a source reference voltage which is electrically connected to the reference electrode. An amplifier is connected to receive power from the power source and to receive the voltage signal from the sensor electrode and the power source reference voltage. The amplifier produces an output signal which is proportional to the voltage signal relative to the power source reference voltage. A filter portion receives the output signal from the amplifier and attenuates electrical activity unrelated to the signal of interest while passing the signal of interest.

¶13 In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the drawings and by study of the following descriptions.

BRIEF DESCRIPTION OF THE DRAWINGS

¶14 Fig. 1 is an illustration of a system which uses a sensor device which measures electrical activity to determine a present time emotional state of a user.

¶15 Fig. 2 is an illustration of a program which contains a display of a level of the present time emotional state of the user and has controls for media material used in guiding the user in relation to the present time emotional state of the user.

¶16 Fig. 3 is a diagram of one example in which the media material guides the user based on the present time emotional state of the user.

¶17 Fig. 4 is a diagram of another example in which the media material guides the user based on the present time emotional state of the user.

¶18 Fig. 5 is a diagram of yet another example in which the media material guides the user based on the present time emotional state of the user.

¶19 Fig. 6 is a perspective view of the sensor device shown in Fig. 1.

¶20 Fig. 7 is a block diagram of the sensor device and a computer shown in Fig. 1.

¶21 Fig. 8 is a circuit diagram of an amplifier used in the sensor device shown in Fig. 7.

¶22 Fig. 9 is a circuit diagram of a filter stage used in the sensor device shown in Fig. 7.

¶23 Fig. 10 is a circuit diagram of a resistor-capacitor RC filter used in the sensor device shown in Fig. 7.

¶24 Fig. 11 is a circuit diagram of the amplifier, three filter stages and the RC filter shown in Figs. 8, 9 and 10.

¶25 Fig. 12 is a block diagram of a digital processor of the sensor device shown in Fig. 7.

DETAILED DESCRIPTION

¶26 A system 30 which incorporates the present discussion is shown in Fig. 1. Exemplary system 30 includes a sensor device 32 which is connected to a user 34 for sensing and isolating a signal of interest from electrical activity in the user's pre-frontal lobe. The signal of interest has a measurable characteristic of electrical activity, or signal of interest, which relates to a present time emotional state (PTES) of user 34. PTES relates to the emotional state of the user at a given time. For instance, if the user is thinking about something that causes the user emotional distress, then the PTES is different than when the user is thinking about something which has a calming affect on the emotions of the user. In another example, when the user feels a limiting emotion regarding thoughts, then the PTES is different than when the user feels a state of release regarding those thoughts. Because of the relationship between the signal of interest and PTES, system 30 is able to determine a level of PTES experienced by user 34 by measuring the electrical activity and isolating a signal of interest from other electrical activity in the user's brain.

¶27 In the present example, sensor device 32 includes a sensor electrode 36 which is positioned at a first point and a reference electrode 38 which is positioned at a second point. The first and second points are placed in a spaced apart relationship while remaining in close proximity to one another. The points are preferably within about 8 inches of one another, and in one instance the points are about 4 inches apart. In the present example, sensor electrode 36 is positioned on the skin of the user's forehead and reference electrode 38 is connected to the user's ear. The reference electrode can also be attached to the user's forehead, which may include positioning the reference electrode over the ear of the user.

¶28 Sensor electrode 36 and reference electrode 38 are connected to an electronics module 40 of sensor device 32, which is positioned near the reference electrode 38 to that they are located substantially in the same noise environment. The electronics module 40 may be located at or above the temple of the user or in other locations where the electronics module 40 is in close proximity to the reference electrode 38. In the present example, a head band 42 or other mounting device holds sensor electrode 36 and electronics module 40 in place near the temple while a clip 44 holds reference electrode 38 to the user's ear. In one instance, the electronics module and reference electrode are positioned relative to one another such that they are capacitively coupled.

¶29 Sensor electrode 36 senses the electrical activity in the user's pre-frontal lobe and electronics module 40 isolates the signal of interest from the other electrical activity present and detected by the sensor electrode. Electronics module 40 includes a wireless transmitter 46, (Fig. 6), which transmits the signal of interest to a wireless receiver 48 over a wireless link 50. Wireless receiver 48, Fig. 1, receives the signal of interest from electronics module 40 and connects to a port 52 of a computer 54, or other device having a processor, with a port connector 53 to transfer the signal of interest from wireless receiver 48 to computer 54. Electronics module 40 includes an LED 55 (Fig. 6), and wireless receiver 48 includes an LED 57 which both illuminate when the wireless transmitter and the wireless receiver are powered.

¶30 In the present example, levels of PTES derived from the signal of interest are displayed in a meter 56, (Figs. 1 and 2), on a computer screen 58 of computer 54. In this instance, computer 54, and screen 58 displaying meter 56 serve as an indicator. Levels of detail of meter 56 can be adjusted to to suit the user. Viewing meter 56 allows user 34 to determine their level of PTES at any particular time in a manner which is objective. The objective feedback obtained from meter 56 is used for guiding the user to improve their PTES and to determine levels of PTES related to particular memories or thoughts which can be brought up in the mind of user 34 when the user is exposed to certain stimuli. Meter 56 includes an indicator 60 which moves vertically up and down a numbered bar 62 to indicated the level of the user's PTES. Meter 56 also includes a minimum level indicator 64 which indicates a minimum level of PTES achieved over a certain period of time or during a session in which user 34 is exposed to stimuli from media material 66. Meter 56 can also include the user's maximum, minimum and average levels of release during a session. Levels of PTES may also be audibly communicated to the user, and in this instance, the computer and speaker serve as the indicator. The levels can also be indicated to the user by printing them on paper.

¶31 In another instance, different release levels relating to reaction to the same media material can be stored over time on a memory device. These different release levels can be displayed next to one another to inform the user on his or her progress in releasing the negative emotions related to the media material.

¶32 In system 30, media material 66 is used to expose user 34 to stimuli designed to cause user 34 to bring up particular thoughts or emotions which are related to a high level of PTES in the user. In the present example, media material 66 includes audio material that is played though computer 54 over a speaker 68. Media material 66 and meter 56 are integrated into a computer program 70 which runs on computer 54 and is displayed on computer screen 58. Media material 66 is controlled using on-screen buttons 72, in this instance. Computer program 70 also has other menu buttons 74 for manipulation of program functions and an indicator 76 which indicates connection strength of the wireless link 50. Program 70 is typically stored in memory of computer 54, this or another memory device can also contain a database for storing self reported journals and self-observed progress.

¶33 In some instances, program 70 may require a response or other input from user 34. In these and other circumstances, user 34 may interact with program 70 using any one or more suitable peripheral or input device, such as a keyboard 78, mouse 80 and/or microphone 82. For instance, mouse 80 may be used to select one of buttons 72 for controlling media material 66.

¶34 Media material 66 allows user 34 to interact with computer 54 for self or assisted inquiry. Media material 66 can be audio, visual, audio and visual, and/or can include written material files or other types of files which are played on or presented by computer 54. Media material 66 can be based on one or more processes, such as "The Release Technique" or others. In some instances, generic topics can be provided in the form of audio-video files presented in the form of pre-described exercises. These exercises can involve typical significant life issues or goals for most individuals, such as money, winning, relationships, and many other popular topics that allow the user to achieve a freedom state regarding these topics. The freedom state about the goal can be displayed when a very low level of PTES, (under some preset threshold) is achieved by the user regarding the goal. The release technique is used as an example in some instances; other processes may also be used with the technological approach described herein.

¶35 In one instance, media material 66 involving "The Release Technique" causes user 34 to bring up a limiting emotion or an emotion-laden experience type of PTES, which results in a disturbance in the nervous system of the user. The process then guides user 34 to normalize the nervous system or release the emotion while the user is focused on the perceived cause of the disturbance. When it is determined that the level of PTES, or release level in this instance, is below a preset threshold then the process is completed.

¶36 The signal of interest which relates to the release level PTES are brain waves or electrical activity in the pre-frontal lobe of the user's brain in the range of 4-12 Hz. These characteristic frequencies of electrical activity are in the Alpha and Theta bands. Alpha band activity is in the 8 to 12 Hz range and Theta band activity is in the 4 to 7 Hz range. A linear relationship between amplitudes of the Alpha and Theta bands is an indication of the release level. When user 34 is in a non-release state, the activity is predominantly in the Theta band and the Alpha band is diminished; and when user 34 is in a release state the activity is predominantly in the Alpha band and the energy in the Theta band is diminished.

¶37 When user 34 releases the emotion, totality of thoughts that remain in the subconscious mind is lowered in the brain as the disturbance is incrementally released from the mind. A high number of thoughts in the subconscious mind results in what is known as unhappiness or melancholy feelings, which are disturbances in the nervous system. A low number of thoughts in the subconscious mind results in what is known as happiness or joyful feelings, which results in a normalization or absence of disturbances in the nervous system.

¶38 An exemplary method 84 which makes use of one or more self or assisted inquiry processes is shown in Fig. 3. Method 84 begins at a start 86 from which the method moves to a step 88. At step 88, program 70 uses stimuli in media material 66 to guide user 34 to bring up thoughts or subjects which causes an emotional disturbance in the PTES such as a limiting emotion. In the present example, media material 66 involves questions or statements directed to user 34 through speaker 68. In this and other instances, the computer can insert statements about goals or issue which were input by the user into the media material 66. For example, user 34 may input a goal statement using keyboard 78 and the computer may generate a voice which inserts the goal statement into the media material. In another example, the user may input the goal statement using microphone 82 and the computer may insert the goal statement into the media material.

¶39 Method 84 then proceeds to step 90 where program 70 uses media material 66 to guide user 34 to release the liming emotions while still focusing on the thought or subject which causes the limiting emotion. From step 90, the program proceeds to step 92 where a determination is made as to whether user 34 has released the limiting emotions. This determination is made using the signal of interest from sensor device 32. In the instance case, the level of release is indicated by the position of indicator 60 on bar 62 in meter 56, as shown in Fig. 2. If the meter indicates that user 34 has released the limiting emotions to an appropriate degree, such as below the preset threshold, then the determination at 92 is yes and method 84 proceeds to end at step 94. If the determination at 92 is that user 34 has not release the limiting emotions to an appropriate degree, then the determination at 92 is no, and method 84 returns to step 88 to again guide the user to bring up the thought or subject causing the limiting emotion. Method 84 can be continued as long as needed for user 34 to release the limiting emotions and achieve the freedom state. Processes can also include clean up sessions in which the user is guided by the media material to release many typical limiting emotions to assist the user in achieving a low thought frequency releasing the limiting emotions.

¶40 By observing meter 56 while attempting to release the limiting emotions, user 34 is able to correlate feelings with the release of limiting emotions. Repeating this process reinforces the correlation so that the user learns what it feels like to release and is able to release effectively with or without the meter 56 by having an increased releasing skill. A loop feature allows the user to click on a button to enter a loop session in which the releasing part of an exercise is repeated continuously. The levels of the user's PTES are indicated to the user and the levels are automatically recorded during these loop sessions for later review. Loop sessions provide a fast way in which to guide a user to let go of limiting emotions surrounding particular thoughts related to particular subjects. The loop session does not require the user to do anything between repetitions which allows them to maintain the desireable state of low thought activity, or the release state. Loop sessions can be included in any process for guiding the user to improve their PTES.

¶41 Computer 54 is also able to record release levels over time to a memory device to enable user 34 to review the releasing progress achieved during a recorded session. Other sessions can be reviewed along side of more recent sessions to illustrate the progress of the user's releasing ability by recalling the sessions from the memory device.

¶42 System 30 is also used for helping user 34 to determine what particular thoughts or subjects affect the user's PTES. An example of this use is a method 100, shown in Fig. 4. Method 100 begins at start 102 from which the method proceeds to step 104. At step 104, user 34 is exposed to a session of media content 42 which contains multiple stimuli that are presented to user 34 over time. Method 100 proceeds to step 106 where the levels of PTES of user 34 are determined during the session while the user is exposed to the multiple stimuli. Following step 106 method proceeds to step 108 where stimulus is selected from the media content 42 which resulted in negative affects on the PTES, such as high emotional limitations. Method 100 therefore identifies for the user areas which results in the negative affects on the PTES. Method 100 then proceeds to step 110 where the selected stimuli is used in a process to help the user release the negative emotions. Method 100 ends at step 112.

¶43 In one example, program 70 uses a method 120, Fig. 5, which includes a questioning pattern called "Advantages/Disadvantages." In this method, the media file asks user 34 several questions in sequence related to advantages/disadvantages of a "certain subject", which causes the user to experience negative emotions. Words or phrases of the "certain subject" can be entered into the computer by the user using one of the input devices, such as keyboard 78, mouse 80 and/or microphone 82 which allows the computer to insert the words or phrases into the questions. System 30 may also have goal documents that have the user's goal statements displayed along with the questioning patterns about the goal and release level data of the user regarding the goal. As an example, the user may have an issue which relates to control, such as a fear of being late for an airline flight. In this instance, the user would enter something like "fear of being late for a flight" as the "certain subject."

¶44 Series of questions related to advantages and disadvantage can be alternated until the state of release, or other PTES, is stabilized as low as possible, that is with the greatest amount of release. Method 120, shown in Fig. 5, starts at a start 122 from which it proceeds to step 124 where program 70 asks user 34 "What advantage/disadvantage is it to me to feel limited by the certain subject?" Program 70 then waits for feedback from the user through one of the input devices.

¶45 Program then proceeds to step 126 where program 70 asks user 34 "Does that bring up a wanting approval, wanting control or wanting to be safe feeling?" Program 70 waits for a response from user 34 from the input device and deciphers which one of the feelings the user responds with, such as "control feeling" for instance. Method 120 then proceeds to step 128 where program 70 questions the user based on the response given to step 128 by asking "Can you let that wanting control feeling go?" in this instance. At this point method 120 proceeds to step 130 where sensor device 32 determines the signal of interest to determine the release level of user 34. The release level is monitored and the media file stops playing when the release level has stabilized at its lowest point. At this time method 120 proceeds to step 132 and the session is complete. When the session is complete, user 34 will feel a sense of freedom regarding the certain subject. If some unwanted emotional residue is left, this same process can be repeated until complete freedom regarding the issue is realized by the user.

¶46 The above method is an example of "polarity releasing" in which an individual is guided to think about positives and negatives about a certain subject or particular issue, until the mind gives up on the negative emotions generated by the thoughts. There are other polarity releasing methods, such as "Likes/Dislikes" and other concepts and methods that help user's to achieve lower though frequency which may also be used along with a sensor device such as sensor device 32 for the purposes described herein.

¶47 Program 70 can store the history of responses to media on a memory device, and combine multiple iterations of responses to the same media in order to create a chart of improvement for user 34. Plotting these responses on the same chart using varying colors and dimensional effects demonstrates to user 34 the various PTES reactions over time to the same media stimulus, demonstrating improvement.

¶48 Program 70 can store reaction to live content as well. Live content can consist of listening to a person or audio in the same physical location, or listening to audio streaming over a telecommunications medium like telephone or the Internet, or text communications. Program 70 can send the PTES data from point-to-point using a communication medium like the Internet. With live content flowing in one direction, and PTES data flowing in the other, the deliverer of live content has a powerful new ability to react and change the content immediately, depending on the PTES data reaction of the individual. This deliverer may be a person or a web server application with the ability to understand and react to changing PTES.

¶49 Program 70 can detect the version of the electronic module 40 latently, based on the type of data and number of bytes being sent. This information is used to turn on and off various features in the program 70, depending on the feature's availability in the electronic module 40.

¶50 With certain types of computers and when certain types of wireless links are used, an incompatibility between wireless receiver 48 and computer 54 may occur. This incompatibility between an open host controller interface (OHCI) of the computer 54 and a universal host controller interface (UHCI) chip in the wireless receiver 48 causes a failure of communication. Program 70 has an ability to detect the symptom of this specific incompatibility and report it to the user. The detection scheme looks for a single response to a ping 'P' from the wireless receiver 48, and all future responses to a ping are ignored. Program 70 then displays a modal warning to the user suggesting workarounds for the incompatibility.

¶51 Program 70 detects the disconnecting of wireless link 50 by continually checking for the arrival of new data. If new data stops coming in, it assumes a wireless link failure, and automatically pauses the media being played and recording of PTES data. On detection of new data coming into the computer 54, the program 70 automatically resumes the media and recording.

¶52 Program 70 can create exercises and set goals for specific PTES levels. For example, it asks the user to set a target level of PTES and continues indefinitely until the user has reached that goal. Program 70 can also store reactions during numerous other activities. These other activities include but are not limited to telephone conversations, meetings, chores, meditation, and organizing. In addition, program 70 can allow users to customize their sessions by selecting audio, title, and length of session.

¶53 Other computing devices, which can include processor based computing devices, (not shown) can be used with sensor device 32 to play media material 66 and display or otherwise indicate the PTES. These devices may be connected to the sensor device 32 utilizing an integrated wireless receiver rather than the separate wireless receiver 48 which plugs into the port of the computer. These devices are more portable than computer 54 which allows the user to monitor the level PTES throughout the day or night which allows the user to liberate the subconscious mind more rapidly. These computing devices can include a camera with an audio recorder for storing and transmitting data to the receiver to store incidents of reactivity on a memory device for review at a later time. These computing devices can also upload reactivity incidents, intensity of these incidents and/or audio-video recordings of these incidents into computer 54 where the Attachment and Aversions process or other process can be used to permanently reduce or eliminate reactivity regarding these incidents.

¶54 One example of sensor device 32 is shown in Figs. 6 and 7. Sensor device 32 includes sensor electrode 36, reference electrode 38 and electronics module 40. The electronics module 40 amplifies the signal of interest by 1,000 to 100,000 times while at the same time insuring that 60 Hz noise is not amplified at any point. Electronics module 40 isolates the signal of interest from undesired electrical activity.

¶55 Sensor device 32 in the present example also includes wireless receiver 48 which receives the signal of interest from the electronics module over wireless link 50 and communicates the signal of interest to computer 54. In the present example, wireless link 50 uses radiofrequency energy; however other wireless technologies may also be used, such as infrared. Using a wireless connection eliminates the need for wires to be connected between the sensor device 32 and computer 54 which electrically isolates sensor device 32 from computer 54.

¶56 Reference electrode 38 is connected to a clip 148 which is used for attaching reference electrode 38 to an ear 150 of user 34, in the present example. Sensor electrode 36 includes a snap or other spring loaded device for attaching sensor electrode 36 to headband 42. Headband 42 also includes a pocket for housing electronics module 40 at a position at the user's temple. Headband 42 is one example of an elastic band which is used for holding the sensor electrode and/or the electronics module 40, another types of elastic bands which provide the same function could also be used, including having the elastic band form a portion of a hat.

¶57 Other types of mounting devices, in addition to the elastic bands, can also be used for holding the sensor electrode against the skin of the user. A holding force holding the sensor electrode against the skin of the user can be in the range of 1 to 4 oz. The holding force can be, for instance, 1.5 oz.

¶58 In another example of a mounting device involves a frame that is similar to an eyeglass frame, which holds the sensor electrode against the skin of the user. The frame can also be used for supporting electronics module 40. The frame is worn by user 34 in a way which is supported by the ears and bridge of the nose of the user, where the sensor electrode 36 contacts the skin of the user.

¶59 Sensor electrode 36 and reference electrode 38 include conductive surface 152 and 154, respectively, that are used for placing in contact with the skin of the user at points where the measurements are to be made. In the present example, the conductive surfaces are composed of a non-reactive material, such as copper, gold, conductive rubber or conductive plastic. Conductive surface 152 of sensor electrode 36 may have a surface area of approximately 1/2 square inch. The conductive surfaces 152 are used to directly contact the skin of the user without having to specially prepare the skin and without having to use a substance to reduce a contact resistance found between the skin and the conductive surfaces.

¶60 Sensor device 32 works with contact resistances as high as 500,000 ohms which allows the device to work with conductive surfaces in direct contact with skin that is not specially prepared. In contrast, special skin preparation and conductive gels or other substances are used with prior EEG electrodes to reduce the contact resistances to around 20,000 ohms or less. One consequence of dealing with higher contact resistance is that noise may be coupled into the measurement. The noise comes from lights and other equipment connected to 60 Hz power, and also from friction of any object moving through the air which creates static electricity. The amplitude of the noise is proportional to the distance between the electronics module 40 and the reference electrode 38. In the present example, by placing the electronics module over the temple area, right above the ear and connecting the reference electrode to the ear, the sensor device 32 does not pick up the noise, or is substantially unaffected by the noise. By positioning the electronics module in the same physical space with the reference electrode and capacitively coupling the electronics module with the reference electrode ensures that a local reference potential 144 in the electronics module and the ear are practically identical in potential. Reference electrode 38 is electrically connected to local reference potential 144 used in a power source 158 for the sensor device 32.

¶61 Power source 158 provides power 146 to electronic components in the module over power conductors. Power source 158 provides the sensor device 32 with reference potential 144 at 0 volts as well as positive and negative source voltages, - VCC and +VCC. Power source 158 makes use of a charge pump for generating the source voltages at a level which is suitable for the electronics module.

¶62 Power source is connected to the other components in the module 40 though a switch 156. Power source 158 can include a timer circuit which causes electronics module 40 to be powered for a certain time before power is disconnected. This feature conserves power for instances where user 34 accidentally leaves the power to electronics module 40 turned on. The power 146 is referenced locally to measurements and does not have any reference connection to an external ground system since sensor circuit 32 uses wireless link 50.

¶63 Sensor electrode 36 is placed in contact with the skin of the user at a point where the electrical activity in the brain is to be sensed or measured. Reference electrode 38 is placed in contact with the skin at a point a small distance away from the point where the sensor electrode is placed. In the present example, this distance is 4 inches, although the distance may be as much as about 8 inches. Longer lengths may add noise to the system since the amplitude of the noise is proportional to the distance between the electronics module and the reference electrode. Electronics module 40 is placed in close proximity to the reference electrode 38. This causes the electronics module 40 to be in the same of electrical and magnetic environment is the reference electrode 38 and electronics module 40 is connected capacitively and through mutual inductance to reference electrode 38. Reference electrode 38 and amplifier 168 are coupled together into the noise environment, and sensor electrode

36 measures the signal of interest a short distance away from the reference electrode to reduce or eliminate the influence of noise on sensor device 32. Reference electrode 38 is connected to the 0V in the power source 158 with a conductor 166.

¶64 Sensor electrode 36 senses electrical activity in the user's brain and generates a voltage signal 160 related thereto which is the potential of the electrical activity at the point where the sensor electrode 36 contacts the user's skin relative to the local reference potential 144. Voltage signal 160 is communicated from the electrode 36 to electronics module 40 over conductor 162. Conductors 162 and 166 are connected to electrodes 36 and 38 in such a way that there is no solder on conductive surfaces 152 and 154. Conductor 162 is as short as practical, and in the present example is approximately 3 inches long. When sensor device 32 is used, conductor 162 is held a distance away from user 34 so that conductor 162 does not couple signals to or from user 34. In the present example, conductor 162 is held at a distance of approximately 1/2" from user 34. No other wires, optical fibers or other types of extensions extend from the electronics module 40, other than the conductors 162 and 166 extending between module 40 and electrodes 36 and 38, since these types of structure tend to pick up electronic noise.

¶65 The electronics module 40 measures or determines electrical activity, which includes the signal of interest and other electrical activity unrelated to the signal of interest which is undesired. Electronics module 40 uses a single ended amplifier 168, (Figs. 7 and 8), which is closely coupled to noise in the environment of the measurement with the reference electrode 38. The single ended amplifier 168 provides a gain of 2 for frequencies up to 12 Hz, which includes electrical activity in the Alpha and Theta bands, and a gain of less than 1 for frequencies 60 Hz and above, including harmonics of 60 Hz.

¶66 Amplifier 168, Figs. 8 and 11, receives the voltage signal 160 from electrode 36 and power 146 from power source 158. Single ended amplifier 168 generates an output signal 174 which is proportional to voltage signal 160. Output signal 174 contains the signal of interest. In the present example, voltage signal 160 is supplied on conductor 162 to a resistor 170 which is connected to non-inverting input of high impedance, low power op amp 172. Output signal 174 is used as feedback to the inverting input of op amp 172 through resistor 176 and capacitor 178 which are connected in parallel. The inverting input of op amp 172 is also connected to reference voltage 144 through a resistor 180.

¶67 Amplifier 168 is connected to a three-stage sensor filter 182 with an output conductor 184 which carries output signal 174. The electrical activity or voltage signal 160 is amplified by each of the stages 168 and 182 while undesired signals, such as those 60 Hz and above, are attenuated by each of the stages. Three-stage sensor filter has three stages 206a, 206b and 206c each having the same design to provide a bandpass filter function which allows signals between 1.2 and 12 Hz to pass with a gain of 5 while attenuating signal lower and higher than these frequencies. The bandpass filter function allows signals in the Alpha and Theta bands to pass while attenuating noise such as 60 Hz and harmonics of the 60 Hz. The three stage sensor filter 182 removes offsets in the signal that are due to biases and offsets in the parts. Each of the three stages is connected to source voltage 146 and reference voltage 144. Each of the three stages generates an output signal 186a, 186b and 186c on an output conductor 188a, 186b and 188c, respectively.

¶68 In the first stage 206a, Figs. 9 and 11, of three-stage sensor filter 182, output signal 174 is supplied to a non-inverting input of a first stage op-amp 190a through a resistor 192a and capacitor 194a. A capacitor 196a and another resistor 198a are connected between the non-inverting input and reference voltage 144. Feedback of the output signal 186a from the first stage is connected to the inverting input of op amp 190a through a resistor 200a and a capacitor 202a which are connected in parallel. The inverting input of op amp 190a is also connected to reference voltage 144 through resistor 204a.

¶69 Second and third stages 206b and 206c, respectively, are arranged in series with first stage 206a. First stage output signal 186a is supplied to second stage 206b through resistor 192b and capacitor 194b to the non-inverting input of op-amp 190b. Second stage output signal 186b is supplied to third stage 206c through resistor 192c and capacitor 194c. Resistor 198b and capacitor 196b are connected between the non-inverting input of op-amp 190b and reference potential 144, and resistor 198c and capacitor 196c are connected between the non-inverting input of op-amp 190c and reference potential 144. Feedback from output conductor 188b to the inverting input of op-amp 190b is through resistor 200b and capacitor 202b and the inverting input of op-amp 190b is also connected to reference potential 144 with resistor 204b. Feedback from output conductor 188c to the inverting input of op-amp 190c is through resistor 200c and capacitor 202c and the inverting input of op-amp 190c is also connected to reference potential 144 with resistor 204c.

¶70 Three stage sensor filter 182 is connected to an RC filter 208, Figs. 10 and 11, with the output conductor 188c which carries the output signal 186c from third stage 206c of three stage sensor filter 182, Fig. 7. RC filter 208 includes a resistor 210 which is connected in series to an output conductor 216, and a capacitor 212 which connects between reference potential 144 and output conductor 216. RC filter serves as a low pass filter to further filter out frequencies above 12 Hz. RC filter 208 produces a filter signal 214 on output conductor 216. RC filter 208 is connected to an analog to digital (A/D) converter 218, Fig. 7.

¶71 A/D converter 218 converts the analog filter signal 214 from the RC filter to a digital signal 220 by sampling the analog filter signal 214 at a sample rate that is a multiple of 60 Hz. In the present example the sample rate is 9600 samples per second. Digital signal 220 is carried to a digital processor 224 on an output conductor 222.

¶72 Digital processor 224, Fig. 7 and 12 provides additional gain, removal of 60 Hz noise, and attenuation of high frequency data. Digital processor 224 many be implemented in software operating on a computing device. Digital processor 224 includes a notch filter 230, Fig. 12 which sums 160 data points of digital signal 220 at a time to produce a 60 Hz data stream that is free from any information at 60 Hz. Following notch filter 230 is an error checker 232. Error checker 232, removes data points that are out of range from the 60 Hz data stream. These out of range data points are either erroneous data or they are cause by some external source other than brain activity.

¶73 After error checker 232, digital processor 224 transforms the data stream using a discreet Fourier transformer 234. While prior EEG systems use band pass filters to select out the Alpha and Theta frequencies, among others, these filters are limited to processing and selecting out continuous periodic functions. By using a Fourier transform, digital processor 224 is able to identify randomly spaced events. Each event has energy in all frequencies, but shorter events will have more energy in higher frequencies and longer events will have more energy in lower frequencies. By looking at the difference between the energy in Alpha and Theta frequencies, the system is able to identify the predominance of longer or shorter events. The difference is then scaled by the total energy in the bands. This causes the output to be based on the type of energy and removes anything tied to amount of energy.

¶74 The Fourier transformer 234 creates a spectrum signal that separates the energy into bins 236a to 236o which each have a different width of frequency. In one example, the spectrum signal has 30 samples and separates the energy spectrum into 2Hz wide bins; in another example, the spectrum signal has 60 samples and separates the bins into 1 Hz wide bins. Bins 236 are added to create energy signals in certain bands. In the present example, bins 236 between 4 and 8 Hz are passed to a summer 238 which sums these bins to create a Theta band energy signal 240; and bins between 8 and 12 Hz are passed to a summer 242 which sums these bins to create an Alpha band energy signal 244.

¶75 In the present example, the Alpha and Theta band energy signals 240 and 244 passed to a calculator 246 which calculates (Theta – Alpha)/Theta + Alpha) and produces an output signal 226 on a conductor 228 as a result.

¶76 Output signal 226, Fig. 7, is passed to wireless transmitter 46 which transmits the output signal 226 to wireless receiver 48 over wireless link 50. In the present example, output signal 226 is the signal of interest which is passed to computer 54 through port 52 and which is used by the computer to produce the PTES for display in meter 56.

¶77 Computer 54 may provide additional processing of output signal 226 in some instances. In the example using the Release Technique, the computer 54 manipulates output signal 226 to determine relative amounts of Alpha and Theta band signals in the output signal to determine levels of release experienced by user 34.

¶78 A sensor device utilizing the above described principles and feature can be used for determining electrical activity in other tissue of the user in addition to the brain tissue just described, such as electrical activity in muscle and heart tissue. In these instances, the sensor electrode is positioned on the skin at the point where the electrical activity is to be measured and the reference electrode and electronics module are positioned nearby with the reference electrode attached to a point near the sensor electrode. The electronics module, in these instances, includes amplification and filtering to isolate the frequencies of the muscle or heart electrical activity while filtering out other frequencies.

¶79 Broadly, this writing discloses apparatus and methods for sensing electrical activity in tissue of a person in a manner which substantially limits or eliminates interference from noise from a surrounding environment.

¶80 While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions and sub-combinations as are within their true spirit and scope.

EEG or brain wave sensors have been around for more than 50 years. In the 60s and 70s there was a lot of work trying to use this data in biofeedback systems. Applications have evolved for EEG measurements including anesthesia monitoring, ADD treatment, epilepsy prediction, and sleep monitoring. The use of the technology has been limited because the systems that are available are expensive ($1000 to $10,000), are cumbersome (take a long time to set up), have wires running everywhere (this is unfriendly to the user), require extensive skin preparation (this includes shaving the hair from the area, sanding the skin to remove the outer surface, putting on a mesh with electrodes and wires running everywhere, and applying a conductive gel or liquid) and requires a trained operator to use them.

The measurement is difficult to make because the electrical signal that is being measured is microvolts in amplitude, and is in an environment which has noise that in on the order of volts or 10s of volts. This gives a signal to noise of 10 ^ - 6. The method that is traditionally used for this measurement is to design a very precise differential amplifier such as an instrumentation amplifier. The amplifier is referenced to a common reference such as the leg of the user. The electronics are connected to the reference by a wire. Two electrodes are applied to two points on the head and connected to the electronics by wire. These two electrode wires are then connected to the inputs of an instrumentation amplifier. The output of the instrumentation amplifier is a voltage (relative to the reference) which is proportional to the difference in voltage between the two electrodes times a constant. This is a very sensitive measurement because they system is finding a small difference between two signals which are very (10^6 times as big) large. Very small variations in the components, routing of the wires, position of noise sources (electrical wires or lights) or motion of the user will cause significant errors in the measurement. This is why the EEG systems are expense and hard to use.

An alternative method has been developed which alleviates the complications of the prior art and allows a simple, robust technique for measuring brain waves, or EEGs. This same method can also be used to simplify the measurement of EKGs and other biometric measurements.

In prior art EEG signals are typically amplified using an instrumentation amplifier or similar differential amplifier design. Instrumentation amplifiers operate by amplifying the difference in voltage between each of the inputs and a reference voltage. The two amplified signals are then subtracted and a voltage is output that represents the difference between the two signals. This output voltage is relative to the reference voltage. The problem is that in an EEG sensor the 60 Hz noise is amplified at the first stage and saturates the signals before they are subtracted. In prior art designers go to great lengths to design systems that balance or shield the noise to avoid this problem. This invention does not use the principle of subtracting two large numbers to get a small number in its measurement or amplification.

This invention is a low cost method for measuring EEG or brain wave data. It uses an isolated single ended amplifier that is closely coupled to the noise environment of the measurement. The invention is to couple a reference electrode and the amplifier into a single coupled noise environment and to measure the EEG signal a short distance away relative to this reference. The invention goes further to disclose an amplifier which amplifies the signal being measured by 1000 to 100,000 times while at the same time insuring that the 60Hz noise is not amplified at any point.

A single conductive surface is placed in contact with the skin at the point that the signal is to be measured. There is no preparation needed for the contact. This conductive surface is composed of any non-reactive material such as copper or gold. A second conductive surface is placed in contact with the skin a small distance away (4 inches). The electronics module is placed in close proximity to the second conductive surface. The electronics module is in the same electrical and magnetic environment as the second conductive surface. The electronics module is connected capacitively and through mutual inductance to the second conductive surface. The first conductive surface is connected to the input of a high impedance, low frequency, single ended amplifier. The second conductive surface is connected to a voltage that is the average of ground and power of the electronics module. The single ended amplifier outputs a signal that is proportional to the voltage at the first conductive surface relative to the second conductive surface. The amplifier further includes a low pass filter that reduces the gain for high frequencies (frequencies above 12 Hz). The whole system is isolated therefore it moves in voltage with interference signals such as 60 Hz noise. The signal is high passed to remove the DC offsets inherent in the measurement. The signal is then amplified through a series of amplification stages. Each stage is designed such that the gain at 60 Hz is less than one. This allows the signal to be amplified without causing saturation at any point due to the 60Hz component. The signal is then digitized using an A/D converter. This signal is averaged for $1/60^{th}$ of a second. This reduces unwanted noise.

The signal is transmitted to display and processing systems using a radio link. This maintains the isolation.

A copper contact (E1) with approximately ½ square inch of surface is connected to a wire (W1). This connection is accomplished such that there is no solder on the contact side of the copper. W1 is connected to the input of the sensor filter first stage (figure 1). This wire is as short as possible. In the preferred embodiment W1 is approximately 3 inches. The wire is maintained such that it is held away from the body a significant distance such that it does not couple signals to or from the body. In the preferred embodiment this distance is approximately ½ inch.

The wire is connected through a resistor (R25) to the positive input of a high impedance, low power op amp. Feedback of the output of the op amp to the negative terminal is provided through a resistor (R24) and a capacitor (C15) connected in parallel as per figure 1. The input of the op amp is also connected to the reference voltage (0V) through a resistor (R23). This configuration provides a gain of 2 for frequencies up to 12 Hz and a gain of less than 1 for frequencies 60 Hz and above. One of the basic principles of the invention is to provide amplification of the signal while at each point in the design (both internal to the amplifiers and external) to provide attenuation (a gain of less than 1) for 60 Hz and above.

The output of the first stage is connected to the first of three identical sensor filter stages. The input network is comprised of a resistor (R21) and a capacitor (C12) in series connecting to the input and a resistor (R22) and a capacitor (C13) connecting the input to (0V) as per figure 2. This network provides a bandpass filter function, allowing signals between 1.2 and 12 Hz to pass with a gain of ½ while attenuating the low and high frequencies. This network removes offsets in the signal that are due to biases and offsets in the parts. Feedback of the output of the op amp to the negative terminal is provided through a resistor (R20) and a capacitor (C11) connected in parallel as per figure 2. The input of the op amp is also connected to the reference voltage (0V) through a resistor (R19). This configuration provides a gain of 5 for frequencies up to 12 Hz and a gain of less than 1 for frequencies 60 Hz and above. The sensor filter described above is repeated two more times as per figure 4.

A second copper contact (E2) is connected to (0V) on the sensor filter (figure 4). The second contact is connected as close as possible to the sensor filter (figure 4). In the preferred embodiment this is less than ¼ inch.

The output is passed through an RC filter comprised of R12 and C7 configured as per figure 4 and then connected to an A/D figure 5.

The analog sensor signal is sampled at high speeds (20 kHz) and input to a digital filter that sums the signal for 1/60th of a second. This filter provides additional gain, removal of 60 Hz noise, and attenuation of high frequency data. The output of this filter is output through a RF link to a receiving station.

Claims

1. A method for measuring EEG, EMG, ECG, or other biometric signals which allows the measurement to be made without surface preparation.
    - A method as per (1) which provides a gravity or spring loaded contact when the apparatus in mounted on the user.
    - A method as per (1) which provides a technique to restrain the apparatus from moving relative to the user during normal motion of the user.
2. A method for measuring EEG, EMG, ECG, or other biometric signals which allows the measurement to be made without wires connected to the user.
    - A method as in (2) which uses a radio transmitter to send data to a computing or display device providing isolation to the measurement.
    - A method as in (2) which uses an infrared transmitter to send data to a computing or display device providing isolation to the measurement.
3. A method for measuring EEG, EMG, ECG, or other biometric signals which allows the measurement to be made with low cost standard electronic components.
    - A method as in (3) which ties the electronics voltages to the voltages at the reference point on the body for the measurement by placing the electronics into close proximity and coupling capacitively and magnetically to the common environment.
    - A method as per (3) which uses one 1.5 volt battery and uses a charge pump to create a higher voltage to operate the electronics.
4. A method for measuring EEG, EMG, ECG, or other biometric signals which uses single ended amplifiers.
    - A method as in (4) which processes the signal though a series of filter / amplifiers which are specifically designed to limit the gain of 60 Hz signals to avoid saturation on nodes internal to the filter / amplifier.
    - A method as in (4) which is designed to use very small voltages (+/- 1.6 volts) while maintaining the integrity of the signals without saturation.
5. A method for measuring EEG, EMG, ECG, or other biometric signals which uses power which is referenced locally to the measurement and does not have any connection or reference to the external world.
    - A method as in (5) which uses a radio transmitter to send data to a computing or display device providing isolation to the measurement.

- A method as in (5) which uses an infrared transmitter to send data to a computing or display device , providing isolation to the measurement.

Exhibit A

6. A method for measuring EEG, EMG, ECG, or other biometric signals which is worn on a structure similar to the design for eyeglasses.

- A method as per (6) which mounts a conductive contact on the top of the frame and allowing it to touch the forehead.
- A method as per (6) which mounts a conductive contact on the arm of the frame and allowing it to touch the ear.
- A method as per (6) which mounts the electronics in very close proximity to the contact on the ear.

7. A method for measuring EEG, EMG, ECG, or other biometric signals which is worn on a structure similar to a headband.

- A method as per (6) which mounts a conductive contact on the inside of the headband and allowing it to touch the forehead.
- A method as per (6) which mounts a conductive contact on the headband and allowing it to touch the ear.
- A method as per (6) which mounts the electronics in very close proximity to the contact on the ear.
- A method as per (6) which mounts a conductive contact on the headband of a hat and allowing it to touch the forehead.
- A method as per (6) which mounts the electronics in the brim of a headband.

8. A method for processing EEG, EMG, ECG signals that substantially avoids interference from 60 Hz noise.

- A method as per (8) that rolls off the signal above 12 Hz.
- A method as per (8) that averages all of the information in each 1/60th of a second or 1 full cycle of 60 Hz noise, thus substantially removing the 60 Hz noise from the signal.
- A method as per (8) that filters and amplifies the signal in small modules which limit the gain at all nodes to less than one for frequencies of 60 Hz and above.
- A method as per (8) that positions the amplifier / filter electronics in the proximity of the reference contact so that the amplifier voltages float up and down similar to voltage of the body at the reference point for the measurement.
- A method as per (8) that transforms the data from time to frequency space and summing the frequencies of interest while ignoring the noise.

Exhibit A

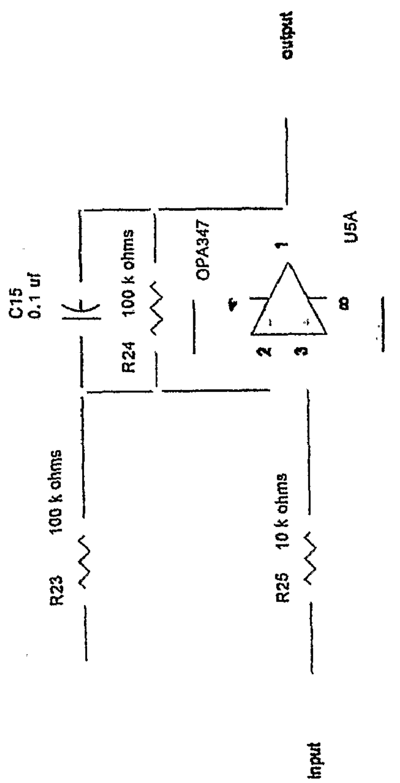


Figure 1

Sensor Filter First Stage

Exhibit A

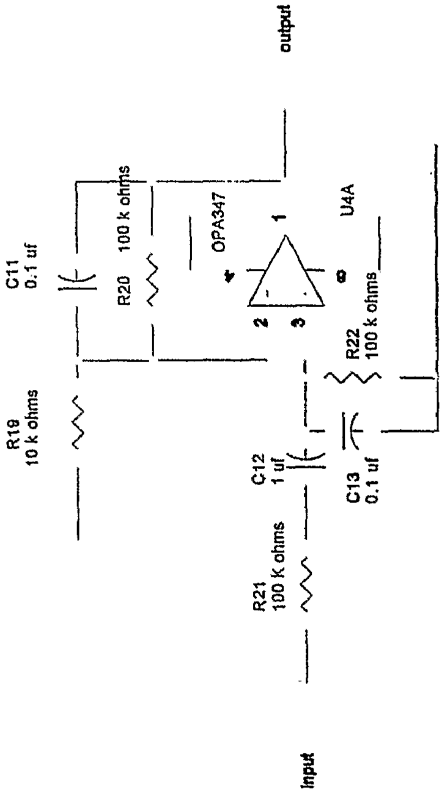


Figure 2

Sensor Filter Stage

Exhibit A

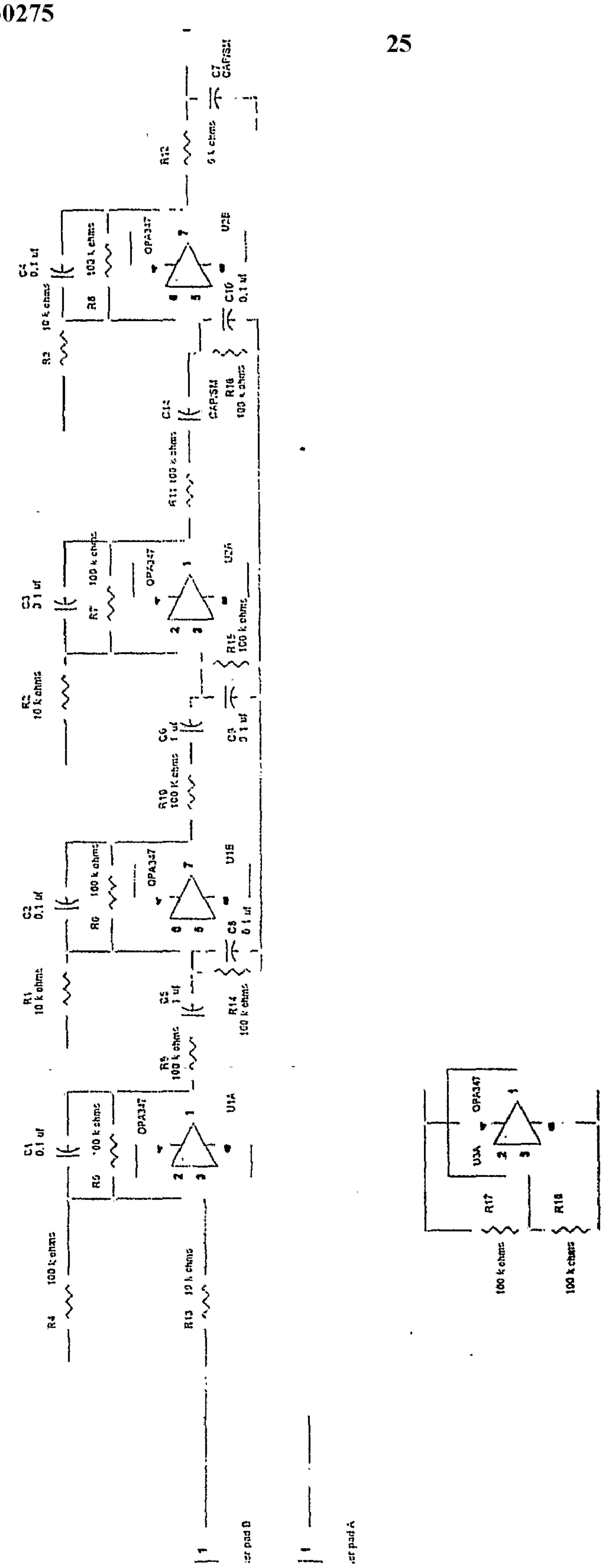


Figure 4
Sensor Filter

What is claimed is:

1. A method for sensing electrical activity in tissue of a user in an environment which can cause electrical noise in electronics, comprising:

detecting the electrical activity from the tissue between a first point and a second point on skin of the user and generating a voltage signal in response thereto which contains a signal of interest and undesired signals;

amplifying the voltage signal to amplify the signal of interest and undesired signals without substantially amplifying the noise, the amplification resulting in an output signal.

2. A method as defined in claim 1 wherein amplifying the voltage signal involves using electronic components which use a local voltage reference, the method further comprising:

connecting the second point directly to the local voltage reference.

3. A method as defined in claim 1 wherein amplifying the voltage signal involves using electronic components which use a local voltage reference and source voltages, the method further comprising;

locating the electronic components in an area in close proximity to the second point so as to substantially couple the local voltage reference and source voltages to the second point.

4. A method as defined in claim 1 wherein amplifying the voltage signal involves using electronic components in an electronics module and detecting the electrical activity involves using conductors extending from the electronics module to electrodes at the first and second points, the method further comprising:

electrically isolating the electronics module by keeping the module free of wires, optical fibers or other extensions other than the conductors extending to the electrodes.

5. A method as defined in claim 1, further comprising;

filtering the output signal to attenuate the undesired signals and isolate the signal of interest from the undesired signals.

6. A method as defined in claim 5, further comprising:

communicating the signal of interest to a computing device.

7. A method as defined in claim 6 wherein the signal of interest is communicated over a wireless link to the computing device.

8. A method as defined in claim 6 wherein the computing device displays information relating to the signal of interest.

9. A method as defined in claim 6 wherein the computing device produces audio related to the signal of interest.

10. A method as defined in claim 5 wherein the signal of interest relates to electrical activity in brain tissue of the user.

11. A method as defined in claim 5 wherein the signal of interest relates to electrical activity in muscle tissue of the user.

12. A method as defined in claim 5 wherein the signal of interest relates to electrical activity in heart tissue of the user.

13. A method as defined in claim 5 wherein filtering the output signal attenuates undesired signals below 4 Hz and above 12 Hz.

14. A method as defined in claim 5 wherein the signals of interest are Alpha and Theta band brain waves.

15. A method as defined in claim 1 wherein the second point is on the ear of the user.

16. A method as defined in claim 1 wherein the second point is approximately 4 inches from the first point.

17. A method as defined in claim 1 wherein the second point is on the forehead of the user.

18. A method as defined in claim 1 wherein the second point is within 8 inches of the first point.

19. A method as defined in claim 1 wherein the undesired signals include noise signals caused by environmental noise.

20. A method for sensing electrical activity in tissue of a user in a noise environment subjected to electrical noise, comprising:

connecting a sensor electrode with skin of the user at a first point;

connecting a reference electrode with skin of the user at a second point which is in a spaced apart relationship to the first point to allow the sensor electrode to sense the electrical activity in the tissue at the first point relative to the second point; and

providing an amplifier which is configured to amplify the electrical activity while substantially reducing the influence from the noise environment.

21. A method as defined in claim 20 wherein connecting the reference electrode with the skin of the user causes a contact resistance between a surface of the reference electrode and the skin, the method further comprising:

configuring the amplifier to allow a surface of the reference electrode to directly contact the skin of the user at the second point without having to prepare the skin or use a material which decreases the contact resistance.

22. A method as defined in claim 21 wherein the amplifier is configured to allow the contact resistance to be as high as 500,000 ohms.

23. A method as defined in claim 20, further comprising:

positioning the amplifier in close proximity to the reference electrode such that the reference electrode and the amplifier are substantially in the same noise environment.

24. A method as defined in claim 20, further comprising:

positioning the amplifier in close proximity to the reference electrode such that the reference electrode and the amplifier are coupled capacitively.

25. A method as defined in claim 20, further comprising:

positioning the amplifier at the temple and the reference electrode at the ear of the user.

26. A method as defined in claim 25 wherein the amplifier and reference electrode are positioned at the right temple and ear of the user.

27. A method as defined in claim 20, further comprising:

isolating a signal of interest from the sensed electrical activity by filtering the amplified electrical activity.

28. A method as defined in claim 27 wherein the signal of interest relates to electrical activity in brain tissue of the user.

29. A method as defined in claim 27 wherein the signal of interest relates to electrical activity in muscle tissue of the user.

30. A method as defined in claim 27 wherein the signal of interest relates to electrical activity in heart tissue of the user.

31. A method as defined in claim 27 wherein filtering the amplified electrical activity attenuates undesired signals below 4 Hz and above 12 Hz.

32. A method as defined in claim 27 wherein the desired signals are Alpha and Theta band brain waves.

33. A method as defined in claim 20 wherein the electrical activity is communicated over a wireless link to a display device.

34. A method as defined in claim 20 wherein the amplifier produces an output signal in analog form, the method further comprising:
converting the output signal from analog to digital.

35. A method as defined in claim 34 wherein the output signal is converted at a rate that is a multiple of 60 Hz.

36. A method as defined in claim 34 wherein the digital output signal is tested for data that is inconsistent with EEG data, and the inconsistent data is removed from the digital output signal.

37. A method as defined in claim 34 wherein the digital output signal is transformed using a discrete Fourier Transform to determine an energy spectrum signal based on the energy spectrum of the digital output signal.

38. A method as defined in claim 37 wherein the energy spectrum signal is divided into groups of 60 samples and separates the energy spectrum into 1 Hz wide bins.

39. A method as defined in claim 37 wherein the energy spectrum signal is divided into groups of 30 samples and separates the energy spectrum into 2 Hz wide bins.

40. A method as defined in claim 37 wherein the energy spectrum signal is divided into groups of samples and separates the energy spectrum in to bins which each represent energy in a certain range of frequencies, and energy in bins that have 4 - 8 Hz are summed to create a Theta band energy signal.

41. A method as defined in claim 40 wherein energy in bins that have 8 - 12 Hz are summed to create an Alpha band energy signal.

42. A method as defined in claim 41 wherein a signal of interest is created by determining a ratio of the Alpha and Theta band energy signals.

43. A method as defined in claim 42 wherein the ratio is (Theta signal – Alpha signal)/(Theta signal + Alpha signal).

44. A method as defined in claim 20 wherein the amplifier produces an output signal in analog form, the method further comprising:

sampling the output signal for a certain number of samples in each $1/60^{th}$ of a second; and

summing the samples from each $1/60^{th}$ of a second to create a processed signal with no 60 Hz interference.

45. A sensor circuit for sensing electrical activity in tissue of a user and isolating and amplifying a signal of interest from the sensed electrical activity, the circuit comprising:

a sensor electrode for placing on skin of the user at a first point;

a reference electrode for placing at a second point which is a distance away from the first point to allow the sensor electrode to sense the electrical activity and to produce a voltage signal relative to the second point which includes the signal of interest in response; and

an electronic module comprising:

a power source with positive and negative source voltages and a source reference voltage which is electrically connected to the reference electrode;

an amplifier connected to receive power from the power source and to receive the voltage signal from the sensor electrode and the power source reference voltage, and wherein the amplifier produces an output signal which is proportional to the voltage signal relative to the power source reference voltage; and

a filter portion which receives the output signal from the amplifier and attenuates electrical activity unrelated to the signal of interest while passing the signal of interest.

46. A sensor circuit as defined in claim 45, further comprising:

a communication section for communicating the signal of interest to a computing device.

47. A sensor circuit as defined in claim 46 wherein the computing device displays information relating to the signal of interest.

48. A sensor circuit as defined in claim 46 wherein the communication section includes a wireless transmitter and a wireless receiver which is used to communicate the signal of interest to the computing device.

49. A sensor circuit as defined in claim 48 wherein the wireless transmitter and receiver use radio frequency waves.

50. A sensor circuit as defined in claim 48 wherein the wireless transmitter and receiver use infrared light.

51. A sensor circuit as defined in claim 45 wherein the sensor electrode includes a surface made from a non-reactive material.

52. A sensor circuit as defined in claim 51 wherein the non-reactive material is copper.

53. A sensor circuit as defined in claim 51 wherein the non-reactive material is gold.

54. A sensor circuit as defined in claim 51 wherein the non-reactive material is a conductive rubber.

55. A sensor circuit as defined in claim 51 wherein the non-reactive material is a conductive plastic.

56. A sensor circuit as defined in claim 45 wherein the distance between the first point and the second point is about 4 inches.

57. A sensor circuit as defined in claim 45 wherein the distance between the first point and the second point is less than 8 inches.

58. A sensor circuit as defined in claim 45 wherein the electrical activity is in brain tissue of the user.

59. A sensor circuit as defined in claim 45 wherein the electrical activity is in heart tissue of the user.

60. A sensor circuit as defined in claim 45 wherein the electrical activity is in muscle tissue of the user.

61. A sensor circuit as defined in claim 45 wherein the power source includes a charge pump.

62. A sensor circuit as defined in claim 45 wherein the signal of interest is from 4 to 12 Hz.

63. A sensor circuit as defined in claim 45 wherein the signal of interest is related to Alpha and Theta band brain waves and the filter attenuates 60 Hz and harmonics of 60 Hz signals.

64. A sensor circuit as defined in claim 45 wherein the first point is on the forehead of the user and the second point is on the right ear of the user.

65. A sensor circuit as defined in claim 45 wherein the sensor electrode is mounted to a frame which is supported by ears and nose bridge of the user.

66. A sensor circuit as defined in claim 65 wherein the electronic module is also supported by the frame.

67. A sensor circuit as defined in claim 45 wherein the sensor electrode is held against the skin of the user at the first point using an elastic band.

68. A sensor circuit as defined in claim 67 wherein the electronic module is supported by the elastic band.

69. A sensor circuit as defined in claim 67 wherein the elastic band extends around the head of the user to hold the sensor electrode against the skin of the forehead of the user at the first point.

70. A sensor circuit as defined in claim 67 wherein the elastic band forms a portion of a hat.

71. A sensor circuit as defined in claim 45 wherein the sensor electrode is held against the skin of the user with a mounting device that provides for 1.5 oz. of force to press the electrode against the skin.

72. A sensor circuit as defined in claim 45 wherein the sensor electrode is held against the skin of the user with a mounting device that provides for 1 to 4 oz. of force to press the electrode against the skin.

73. A sensor circuit as defined in claim 45 wherein the electronic module further comprises:

an averaging circuit for removing substantially all 60 Hz and harmonics of 60 Hz signals from the signal of interest.

74. A system for sensing electrical activity in tissue of a user, comprising:

means for detecting electrical activity from the tissue of the user at a first point on the skin of the user relative to a second point which is in a spaced apart relationship to the first point and generating a voltage signal in response thereto which contains a signal of interest and undesired signals;

means for amplifying the voltage signal to amplify the signal of interest and the undesired signals without substantially amplifying the noise, the amplification resulting in an output signal.

75. A system for sensing electrical activity in tissue of a user, comprising:

an arrangement which detects electrical activity from the tissue of the user at a first point on the skin of the user relative to a second point which is in a spaced apart relationship to the first point and generating a voltage signal in response thereto which contains a signal of interest and undesired signals;

an arrangement which amplifies the voltage signal to amplify the signal of interest and the undesired signals without substantially amplifying the noise, the amplification resulting in an output signal.

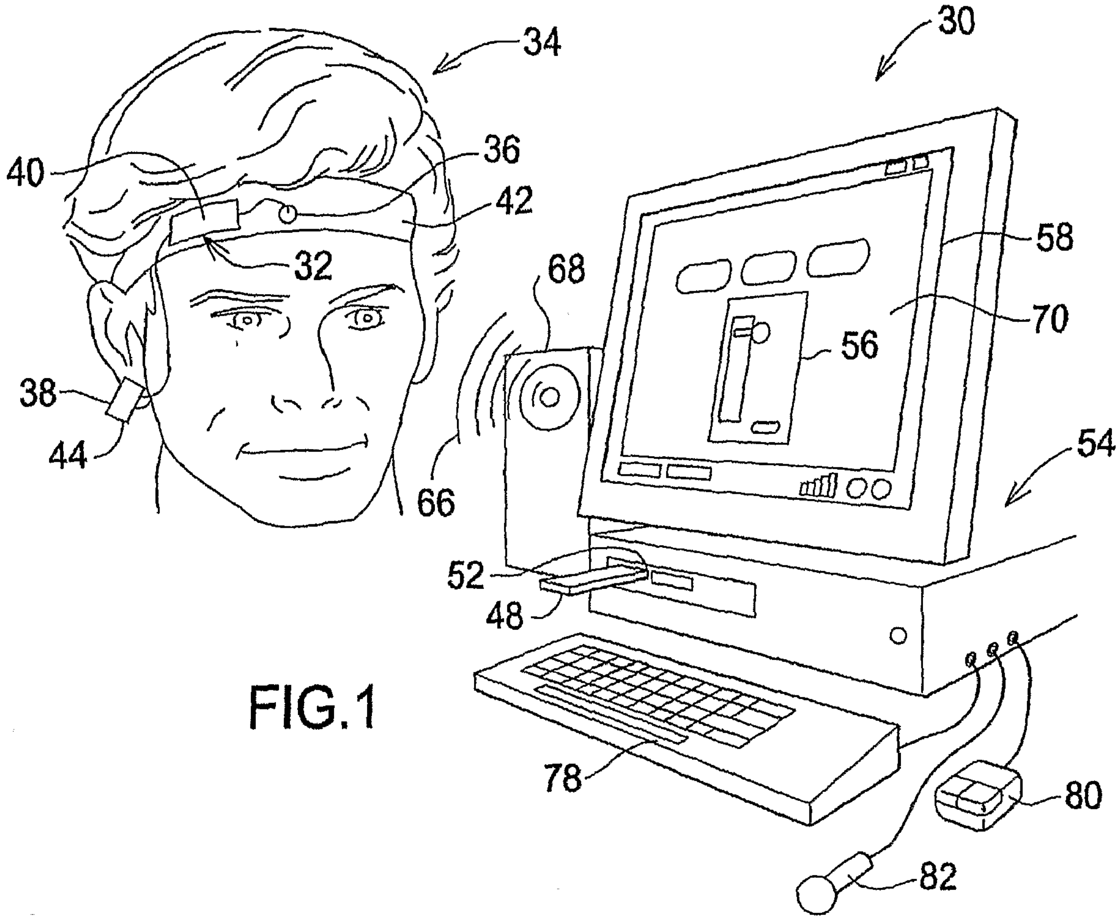

34
30
40
36
42
32
58
68
70
56
38
54
44
66
52
48
78
80
82

FIG.1

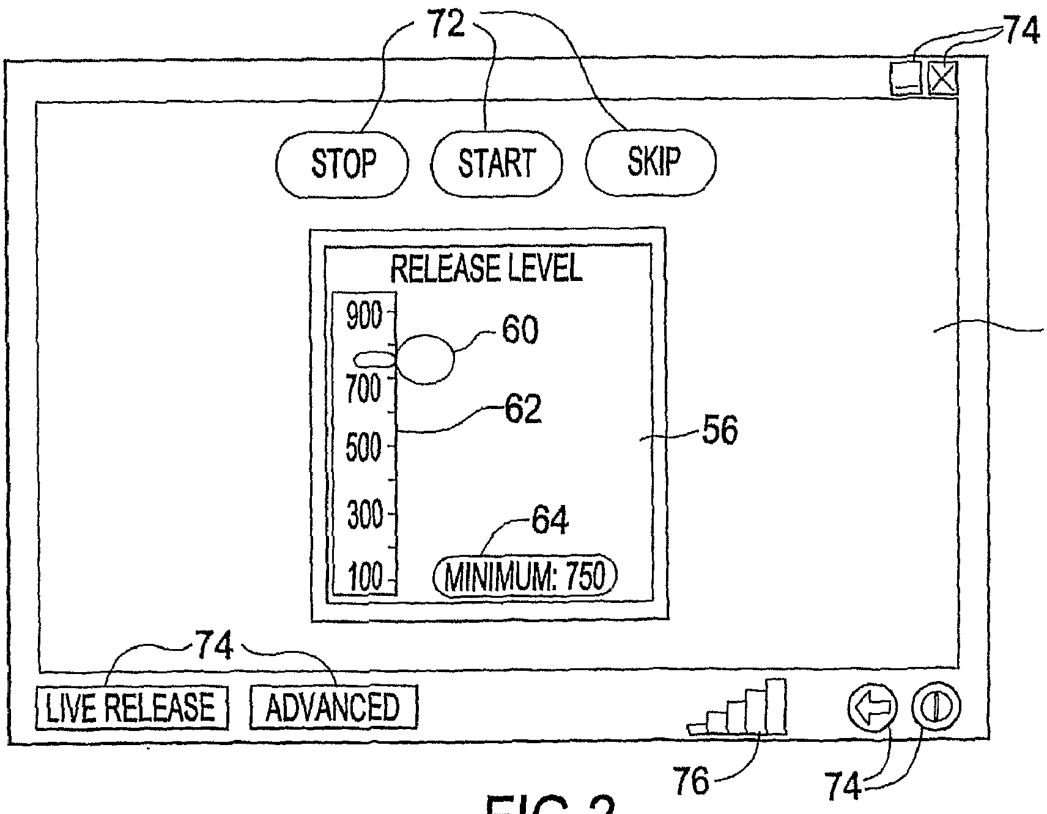

72
74
STOP
START
SKIP
RELEASE LEVEL
900
60
700
62
500
300
64
100
MINIMUM: 750
70
56
74
LIVE RELEASE
ADVANCED
76
74

FIG 2

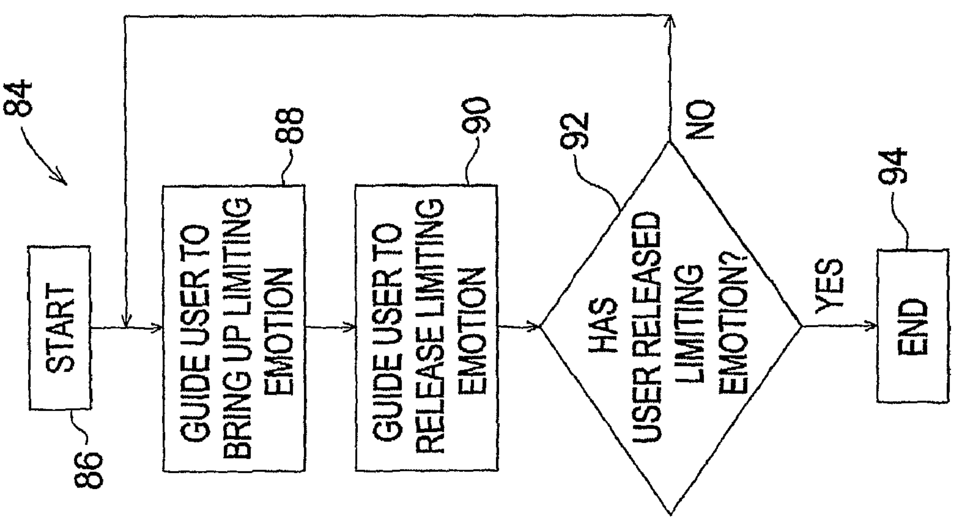

84
START
86
GUIDE USER TO BRING UP LIMITING EMOTION
88
GUIDE USER TO RELEASE LIMITING EMOTION
90
HAS USER RELEASED LIMITING EMOTION?
92
NO
YES
END
94

FIG.3

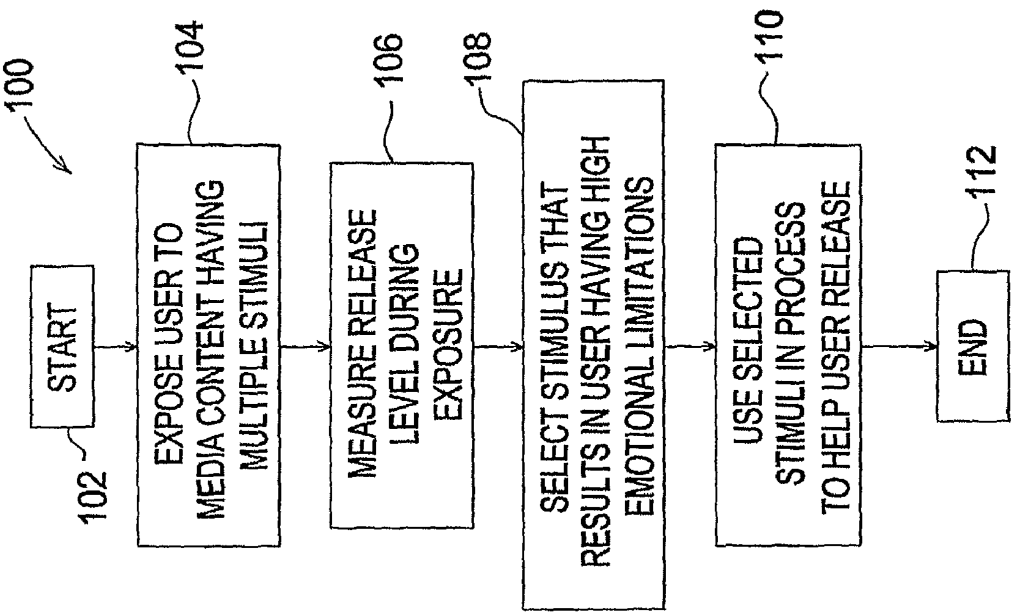

100
START
102
EXPOSE USER TO MEDIA CONTENT HAVING MULTIPLE STIMULI
104
MEASURE RELEASE LEVEL DURING EXPOSURE
106
SELECT STIMULUS THAT RESULTS IN USER HAVING HIGH EMOTIONAL LIMITATIONS
108
USE SELECTED STIMULI IN PROCESS TO HELP USER RELEASE
110
END
112

FIG.4

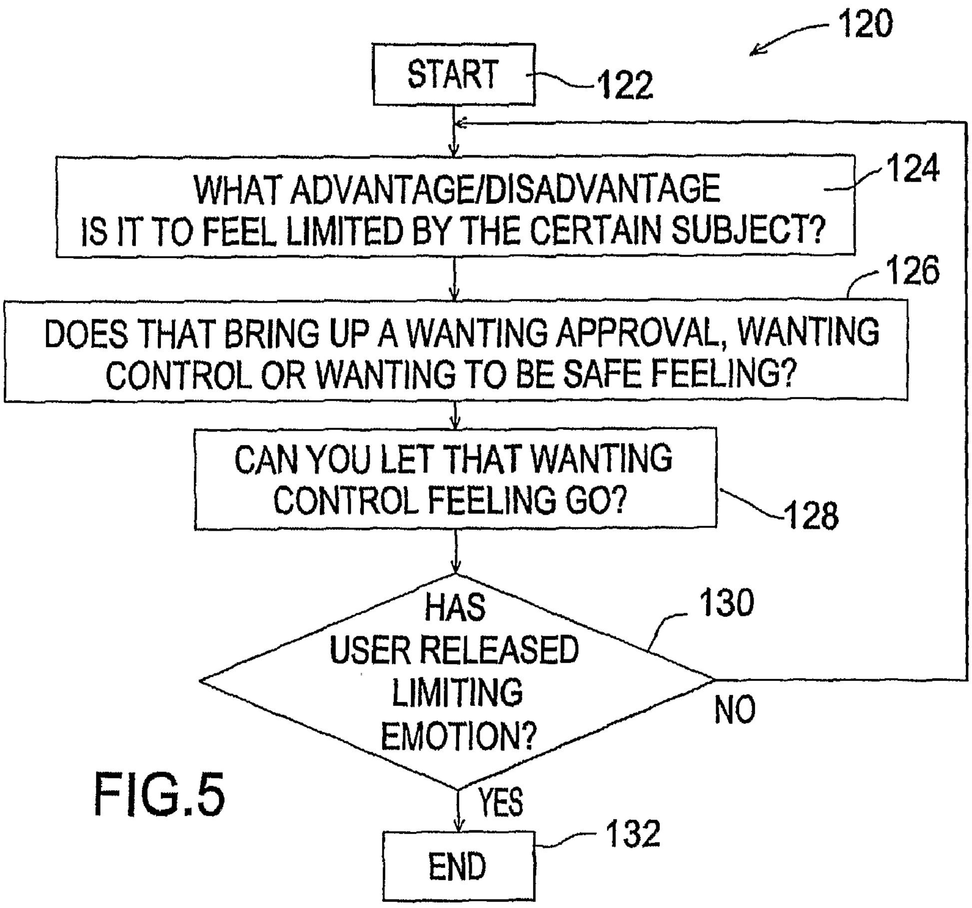

120
START
122
WHAT ADVANTAGE/DISADVANTAGE IS IT TO FEEL LIMITED BY THE CERTAIN SUBJECT?
124
DOES THAT BRING UP A WANTING APPROVAL, WANTING CONTROL OR WANTING TO BE SAFE FEELING?
126
CAN YOU LET THAT WANTING CONTROL FEELING GO?
128
HAS USER RELEASED LIMITING EMOTION?
130
NO
YES
END
132

FIG.5

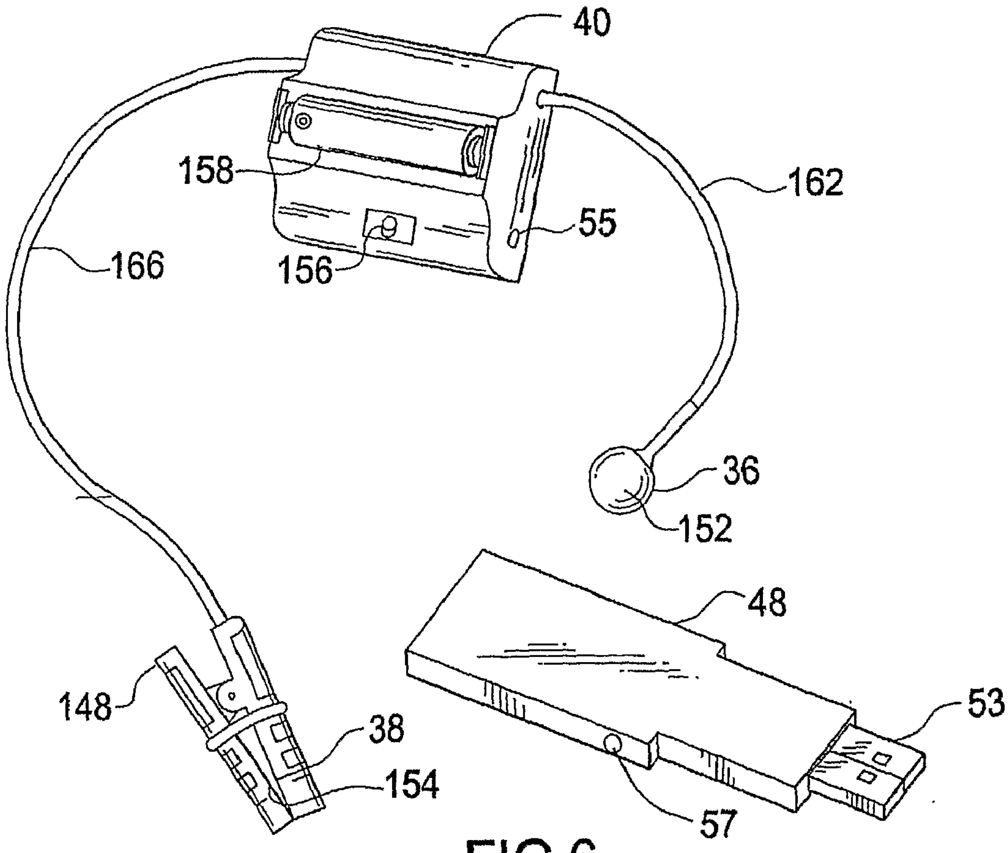
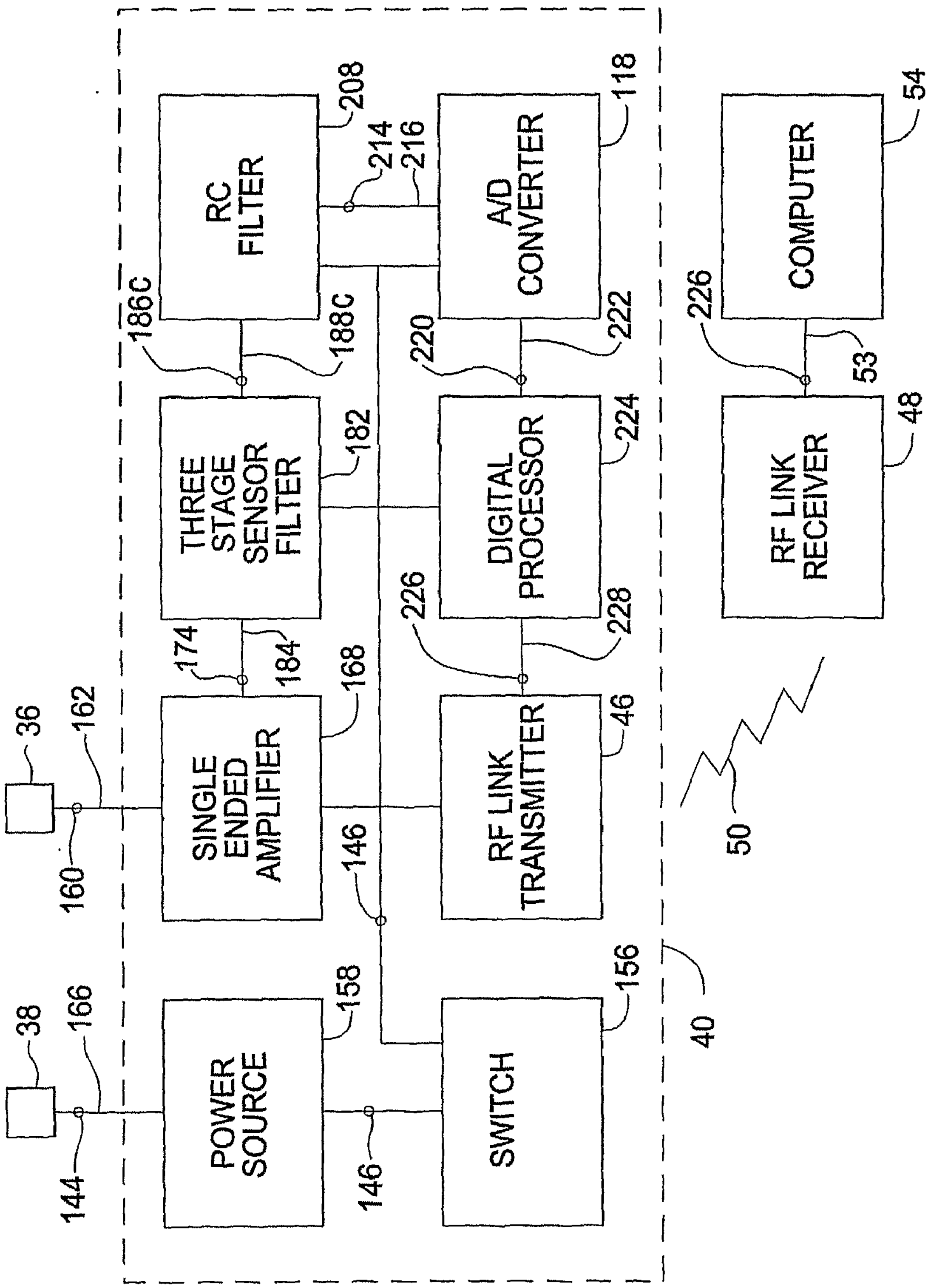

40
158
162
55
166
156
36
152
48
148
38
53
154
57

FIG.6


RC FILTER
A/D CONVERTER
COMPUTER
THREE STAGE SENSOR FILTER
DIGITAL PROCESSOR
RF LINK RECEIVER
SINGLE ENDED AMPLIFIER
RF LINK TRANSMITTER
POWER SOURCE
SWITCH
208
214
216
118
54
186C
188C
220
222
226
53
182
224
48
174
184
168
226
228
36
162
160
146
46
50
38
166
158
156
40
144
146
FIG.7

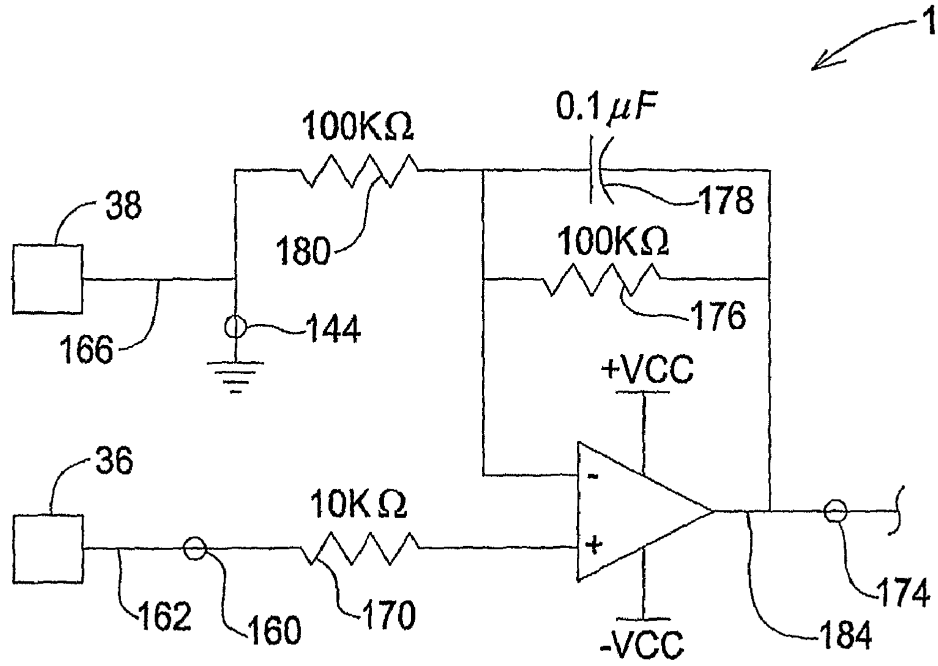

168
100KΩ
0.1μF
38
178
180
100KΩ
176
166
144
+VCC
36
10KΩ
162
160
170
-VCC
184
174

FIG.8

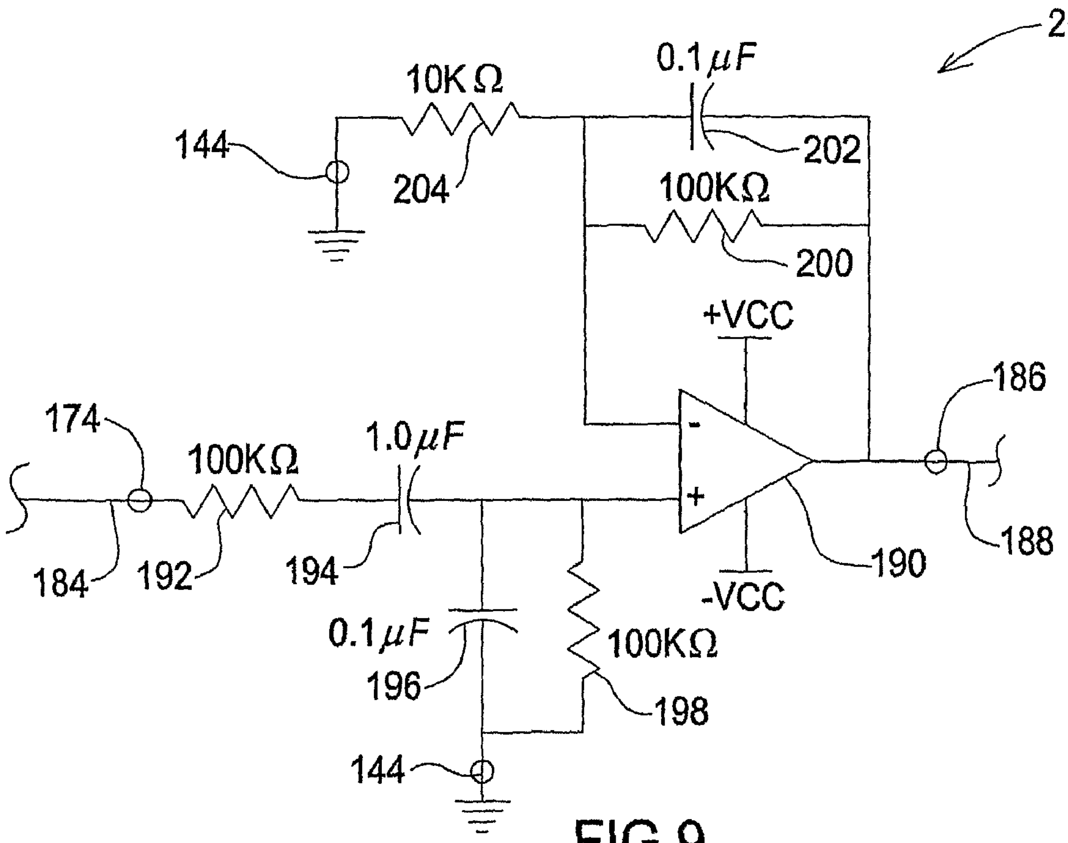

206
10KΩ
0.1μF
144
202
204
100KΩ
200
+VCC
174
186
100KΩ
1.0μF
184
192
194
190
188
-VCC
0.1μF
100KΩ
196
198
144

FIG.9

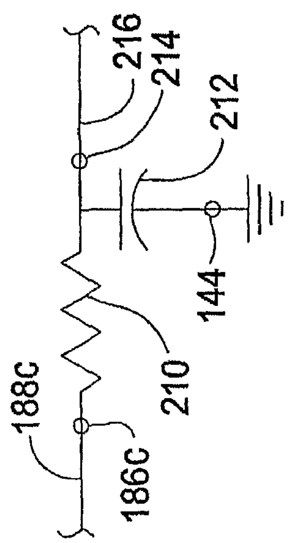

188c
186c
210
144
212
214
216

FIG.10

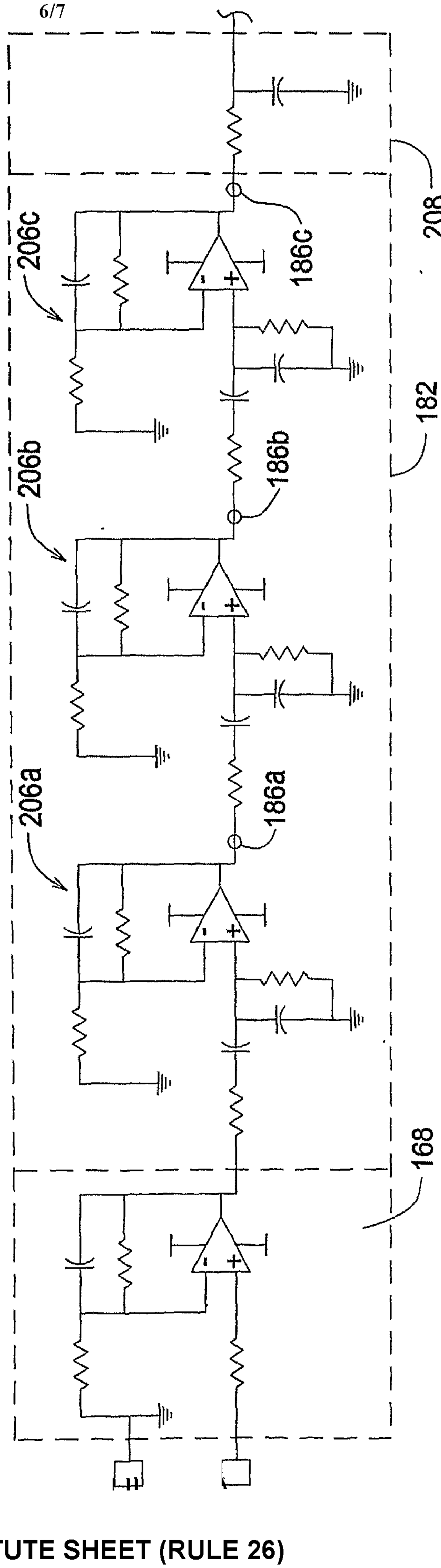

206a
206b
206c
186a
186b
186c
208
182
168

FIG.11

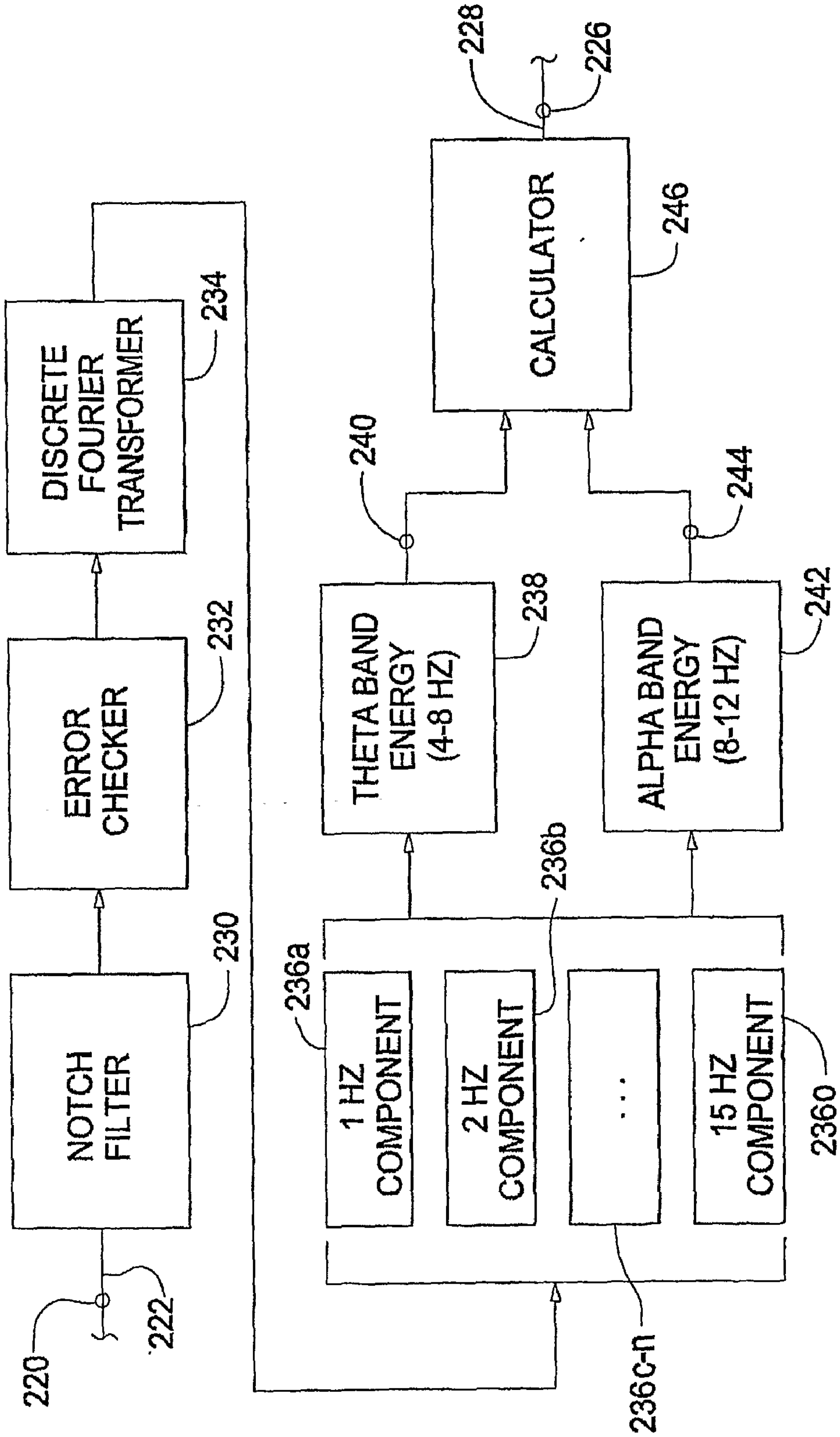

220
222
NOTCH FILTER
230
ERROR CHECKER
232
DISCRETE FOURIER TRANSFORMER
234
236a
1 HZ COMPONENT
236b
2 HZ COMPONENT
...
15 HZ COMPONENT
236o
236c-n
THETA BAND ENERGY (4-8 HZ)
238
ALPHA BAND ENERGY (8-12 HZ)
242
240
244
CALCULATOR
246
228
226

FIG.12

专利名称(译)	一种用于感测组织中的电活动的装置和方法		
公开(公告)号	EP1921986A4	公开(公告)日	2011-11-30
申请号	EP2006824810	申请日	2006-08-08
[标]申请(专利权)人(译)	埃姆申塞公司		
申请(专利权)人(译)	EMSENSE CORPORATION		
当前申请(专利权)人(译)	EMSENSE CORPORATION		
[标]发明人	LEE MICHAEL J LEE HANS C		
发明人	LEE, MICHAEL J. LEE, HANS C.		
IPC分类号	A61B5/00 A61B5/04 A61B5/0476 A61B5/048		
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优先权	60/713899 2005-09-02 US		
其他公开文献	EP1921986A2		
外部链接	Espacenet		

摘要(译)

提供一个或多个改进的示例性实施例包括用于以基本上限制或消除周围环境中的噪声干扰的方式感测人的组织中的电活动的装置和方法。