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(54) METHOD AND APPARATUS FOR EXAMINING SUBJECTS FOR PARTICULAR PHYSIOLOGICAL CONDITIONS UTILIZING ACOUSTIC INFORMATION

VERFAHREN UND VORRICHTUNG ZUR UNTERSUCHUNG VON PERSONEN AUF SPEZIELLE PHYSIOLOGISCHE ZUSTÄNDE ANHAND AKUSTISCHER INFORMATIONEN

PROCÉDÉ ET APPAREIL POUR L EXAMEN DE SUJETS À LA RECHERCHE DE CONDITIONS PHYSIOLOGIQUES PARTICULIÈRES EN UTILISANT DES INFORMATIONS ACOUSTIQUES

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Description

RELATED APPLICATIONS

[0001] The present application includes the subject matter of US Provisional Application No. 61/071,992 filed May 29, 2008, and claims the priority date of that provisional application.

FIELD AND BACKGROUND OF THE INVENTION

[0002] The present invention relates to methods and apparatus for examining subjects for particular physiological conditions using acoustic information. The invention is particularly useful in known techniques which utilize sounds generated by the subject and sensed at a predefined distance from the site of sound generation of the subject's body, e.g., one meter, and is therefore described below with respect to such techniques.

[0003] The measurement of the acoustic characteristics of certain body functions, particularly those related to breathing, or cessation of breathing, or partial cessation of breathing provides valuable medical information. Cases in point include, but are not limited to, the measurement of snoring intensity, which is an important medical parameter particularly in the domain of sleep medicine. Other examples related to the respiratory system include the intensity of wheezing, stridor, (high-pitched sounds), coughing, respiratory rates, etc., which are clinically important in diagnosing various respiratory system conditions. In addition, sounds related to the cardiovascular system, such as the well known 'heart sounds', sounds related to the musculoskeletal system, sounds related to the gastro-intestinal system, and sounds related to specific measurement methods, such as blood pressure measurements, are also clinically important.

[0004] Measurement of the intensity of snoring is important in providing an index of the state of a patient's respiratory activity and the state of the airways during sleep. It is affected by, among other physiological factors, the degree of patency of a patient's airways, the upper airway muscle tone, mucosal swelling, and the degree of respiratory drive particularly during sleep. Measurement of the frequency spectrum of snoring sounds may also provide useful clinical information, for example, in determining the main site of the snores origin in the subject's respiratory system. Quantitative calibration of such acoustic activity is essential for enabling the medical practitioner to gage the clinical significance of, for example, a subject's snoring activity, as a part of the diagnostic process. Traditionally, the intensity of snoring sounds has been determined as the decibel level of such sounds at some predefined distance, commonly one meter from the site of sound generation. Established clinical criteria for quantifying snoring intensity are defined in this manner. In clinical laboratory based medicine, and in particular in the sleep medicine clinic setting, the recording of a subject's acoustic activity is traditionally performed by placing a sound level recorder, such as a microphone, at a predefined distance (e.g., one meter) from the subject. The setting up of such an acoustic measurement environment calls for considerable technical expertise and is thus clearly not suitable for performing measurements outside the confines of specialized laboratories. It is also highly susceptible to environmental acoustic activity, such as other snoring bed partners, audio devices etc., which may seriously confound the accurate measurement of a given subject's breathing activity. In practice, measurements outside the specialist laboratory are being increasingly applied. In particular, these include ambulatory measurement systems which assume an important role in clinical medicine, and are particularly valuable in sleep medicine. The advantages of ambulatory testing are numerous and well known, and include increased patient comfort, accessibility, as well as considerable cost saving. A major advantage, among others, in recording respiratory sound activity directly from the subject's body surface is that it considerably reduces the problem of acoustic crosstalk due to environmental noise activity, which problem is inherent to sound level measurement at a fixed distance from the subject. The acoustic quality associated with various physiological systems may also be influenced by the movement of the body at the examination site, and also the position, posture or orientation, with respect to gravity, of the body at the examination site. Moreover, diagnosing many physiological conditions utilize not only acoustic information, but also such position and/or motion information.

[0005] The determination of multiple physiological signals, including body position, body movement and acoustic measurements related to physiological processes of the body, have been involved in a number of patent publications, including U.S. Patents 4,784,162, 5,275,159, 6,171,258 and U.S. Patent Application 2005/0113646 A1. In these prior patent applications the measurements of body position, body movement and/or acoustic activity, was generally achieved by using separate sensors on the body surface. These sensors were not designed to enable measurement from a single common location, nor were they configured to permit them to be arranged in such a way as to facilitate measurement from a single location.

[0006] Other patent publications relative to this field are U.S. Patents 6,468,234, 7,077,810, and International PCT Application of International Publication No. WO2005/120167. However, the developments described therein do not use acoustical or sound sensors, but rather vibration sensors sensing vibrations of the subject's body.

[0007] Another patent is U.S. Patent 6,213,955, relating to "A sensor is exposed to the acoustic duct and senses turbulence and/or vibration and/or sound in the air flow in the acoustic duct to provide an electric output signal. The electrical signal is digitally processed to provide a real-time signal indicative of breathing of the patient."

[0008] There are several reasons why obtaining infor-

mation concerning the body position, body movement and acoustic measurements from a common site wherein the means for obtaining this information are housed within a common housing is beneficial to the assessment of a variety of physiological and pathological conditions, as illustrated by the following examples:

Application for respiratory system

[0009] The occurrence of upper-airway increased resistance, or even complete collapse, is a hallmark of the well known obstructive sleep apnea (OSA) syndrome. An obstructive event in a patient with OSA is usually preceded by considerable acoustic activity or snoring, however this ceases when the flow of air is sufficiently attenuated due to the progression of airway narrowing.

[0010] The disappearance of snoring may, on the other hand, merely be due to a reversal of the partial airway obstruction which caused the snoring. Distinguishing between these two extreme situations may be facilitated by measuring surface motion at the measurement site. In the case of the worsening obstruction, increased surface motion which is sub-acoustic in nature is likely to be present by ongoing vibration of the tissues due to large pressure perturbations at the site of obstruction brought about by ineffectual breathing effort. An appropriate motion sensor will enable this to be sensed.

[0011] Although there are a number of locations on the body surface that may be appropriate for recording acoustic, and/or vibratory activity associated with snoring and sleep disordered breathing conditions, we have found that the best site for such measurements is the extra thoracic region extending from the chin to the sternum, and the thoracic region surrounding the supra-sternal notch. At these sites the sound and surface motion signals are best recorded due to close proximity to the source of the perturbations, and due to there being mainly soft tissues between the body surface and the airway lumen.

[0012] In order to effectively measure these multiple parameters from this region, it is highly desirable to obtain the full set of body position, body movement and acoustic information measurements from a single location. The present invention specifically addresses this objective.

Application for blood pressure measurements

[0013] There are a number of well known methods for performing non-invasive blood pressure measurements. Two of the most common are the so called "Auscultatory" method and the "oscillometric" method, respectively.

[0014] In the ausculatory method, acoustic information detected by stethoscope, associated with varying degrees of arterial opening during the progressive deflation of the blood pressure cuff, are sensed, and according to the quality of the associated sound, the respective systolic and diastolic pressure values may be determined. This is the most commonly used method in clinical practice, and the so "Korotkoff" sounds are used to define the blood pressure values. Automatic devices which analyze the acoustic information are also available.

[0015] The second commonly used blood pressure measurement method is the so called "oscillometric" method, which is based on detecting fluctuations in the volume of the measured limb segment associated with varying degrees of arterial opening during the progressive deflation of the blood pressure cuff. According to the amplitude of the associated volume changes, the respective systolic, mean and derived diastolic pressure values may be determined. Sensing of the volume change is usually based on pressure change in the cuff or the magnitude of the skin motion in the vicinity of the measured artery.

[0016] In both of the above methods, the inventive device of the current application would have distinct advantages over either method alone since it would be able to provide the source information needed for the determination of BP according to both methods.

[0017] Furthermore, the addition of a body position detecting means in, for example, the traditional measurement of BP from brachial artery of the arm, would provide important information regarding the orientation of the measurement site, which could for instance be used to determine the hydrostatic offset of the arm in a seated patient, based on the angle of the arm with respect to the long axis of the body.

[0018] Finally, in the above application, accurate positioning of the sensor is critical to the success of the measurement since the location of the pulsating area is highly limited. Only an apparatus having all the sensors located at the exact site would provide sufficiently reliable data.

Cardiology

[0019] The application of both acoustic and surface motion sensing, as well as body position determination from a single common site, wherein the means for obtaining this information are housed within a common housing, may provide useful information about heart function, as illustrated in the following example.

[0020] The detection of heart sounds is a commonly used clinical practice which is particularly helpful in, among other things, detecting valvular heart disease conditions.

[0021] The clinical interpretation of the significance of the heart sounds may be affected by a patient's breathing. For example, in the so called second heart sound (which, is caused by reverberations within the blood and surrounding tissues associated with the sudden blocking of retrograde blood flow due to closure of the aortic valve and pulmonary valve respectively at the end of ventricular systole), knowledge of the patient's breathing can enable a diagnosis to be made by helping to determine if the "splitting" of the heart sound is pathological or physiological in nature.

[0022] In essence, this is related to the effect of intra-

thoracic pressure on blood return into the right side of the heart. During inspiration, greater negative intra-thoracic pressure is generated which increases the blood volume in the right ventricle. This prolongs the time that the pulmonary valve stays open relative to the aortic valve.

[0023] This situation thus results in a physiological "splitting" of the second heart sound.

[0024] If however, this splitting does not vary with inspiration, it may represent a pathological state, possibly due to a left-to-right shunt of blood within the heart itself. This raises the concern of an atrial or ventricular septal defect.

[0025] Certain clinical interventions can be performed to increase the venous return to the right side of the heart, including the adoption of a supine posture, which can enhance the above described diagnosis.

[0026] In the above described example, a combined body position, body movement, and acoustic measurements apparatus would be very useful since it would facilitate the accurate recording of the heart sounds via the acoustic sensing means, the breathing pattern via the combination of body position and body movement signals, and the patients posture by the body position sensor, when it is appropriately placed on the patient's chest wall.

[0027] In addition, vibrations related to the mechanical perturbations associated with heart valve closure, and pathological conditions thereof, which are sub-acoustic in nature, may be present at the signal measurement site. An appropriate motion sensor will enable this to be sensed.

[0028] As was the case in the previously cited examples, here too, accurate positioning of the sensor is critical to the success of the measurement since the location at which heart sounds, and particularly splitting of the second heart sound area, is highly limited. Only an apparatus having all the sensors located at the exact site would provide sufficiently reliable data.

Rheumatology

[0029] The combined body position, body movement, and acoustic measurements apparatus may also be useful for quantitatively detecting and analyzing joint disorders by measuring joint movements related to sound patterns.

[0030] Since the apparatus can be used to provide a limb's position in 3D space over time, and can be used to characterize the dynamics the limb movements, the associated sound information may therefore provide a quantitative assessment of the degree of joint damage. As was the case in the previously cited examples, here too, accurate positioning of the sensor is critical to the success of the measurement. Clearly, given the limited space available for placing the apparatus at the joint location, only an apparatus having all the sensors located at the exact site would enable the measurements to be properly made to provide sufficiently reliable data.

Gastroenterology

[0031] The evaluation of several physiological processes related to the gastrointestinal system may be beneficially performed by using a combined body position, body movement, and acoustic measurements apparatus and the appropriate signal analysis. Such processes as swallowing (deglutition), peristalsis, bowel sounds, bowel transit time, may be thus analyzed. Furthermore, the use of multiple units may be beneficially applied at appropriate body sites to facilitate the evaluation. For example, applying multiple units on the surface of the abdomen overlying the intestines may be useful in determining the bowel transit time and the kinetics of bowel action and its disorders. Likewise, when applied to the throat/neck and thorax regions such units may be useful in evaluating swallowing and related disorders.

OBJECTS AND BRIEF SUMMARY OF THE PRESENT INVENTION

[0032] One object of the present invention is to provide a method, and also apparatus, for examining a subject for a particular physiological condition by a technique utilizing acoustic activity of the subject issued at a particular location on the subject's body, and therefore having advantages in one or more of the above respects. Another object of the present invention is to provide a method and apparatus for measuring a large number of physiological conditions of a subject by utilizing, not only the measurements of acoustic activity, but also the measurements of position and/or motion of the subject at the examination site.

[0033] These objects are achieved according to the present invention by the method defined in claim 1 and the apparatus defined in claim 8.

[0034] According to one aspect of the present invention, there is provided a method of examining a subject for a particular physiological condition by a technique utilizing sounds generated by the subject and sensed at a predefined distance from the site of sound generation of the subject's body, comprising: locating a first sound sensor at a particular region of the subject's body to produce an output corresponding to the sounds sensed by the first sound sensor; modifying the output of the first sound sensor by a pre-calculated Transfer Function equating the output of the first sound sensor with that of a second sound sensor located at a predetermined distance from the subject's body; and utilizing the modified output of the first sound sensor in determining the existence of the particular physiological condition.

[0035] In the described preferred embodiments, the Transfer Function is pre-calibrated by: locating the first sound sensor on the particular region of the subject's body; locating the second sound sensor at the predefined distance from the site of sound generation of the subject's

body; simultaneously detecting the sounds sensed by the first and second sensors to produce outputs corresponding thereto; and processing the outputs of the first and second sound sensors to calculate the Transfer Function equating the output of the first sound sensor with that of the second sound sensor.

[0036] The first sound sensor located on the particular region of the subject's body may be pre-calibrated to compensate for ambient noise at the particular time it is used for examining the subject for a particular physiological condition, by applying a reference sound generator to the region of the first sound sensor; actuating the reference sound generator simultaneously with the actuation of the first and second sound sensors; processing the two outputs of the first and second sound sensors to determine the difference between the two, which difference represents an Ambient Noise Factor (ANF); and modifying the calculated Transfer Function by the Ambient Noise Factor.

[0037] According to another aspect of the present invention, there is provided a method of examining a subject for a particular physiological condition by a technique utilizing sounds generated by the subject and sensed at a predefined distance from the subject, comprising: locating a first sound sensor on a particular region of the subject's body to produce an output corresponding to the sound sensed by the first sound sensor; modifying the output of the first sound sensor by a pre-calculated Ambient Noise Factor equating the output of the first sound sensor with that of a second sound sensor located at a predetermined distance from the subject's body; and utilizing the modified output of the first sound sensor for determining the existence of the particular physiological condition.

[0038] According to further features of the invention, the position, and/or motion, of the subject's body at which the first sound sensor is located is also sensed by a position and/or motion sensor located at the particular region of the subject's body, and produces an output which it also utilized to determine the existence of particular physiological condition. By providing the additional position and/or motion sensor on the patient's body at the same location as that of the sound sensor provides the advantages as discussed above making the method particularly useful for sensing snoring or a breathing disorder, sensing blood pressure or other cardiovascular condition of the subject, a joint disorder of the subject involving joint movement related to sound patterns, or a parameter related to the gastrointestinal condition of the subject, as briefly described above.

[0039] According to a still further aspect of the invention, there is provided apparatus for examining a subject for a particular physiological condition by a technique utilizing sounds generated by the subject and sensed at a predefined distance from the site of sound generation of the subject's body, comprising: a first sensor constructed to be located at a particular region of the subject's body to produce an output corresponding to the sounds sensed by the first sound sensor; a second sound sensor constructed to be located at a predefined distance from the subject's body, and to produce an output corresponding to the sounds sensed by the second sound sensor; and a processor effective to receive simultaneously the outputs of the two sound sensors, to calculate therefrom a Transfer Function equating the output of the first sound sensor with that of the second sound sensor, to utilize the Transfer Function for modifying the output of first the first sound sensor, and to utilize the modified output of the first sound sensor for producing information useful in determining the existence of the particular physiological condition.

[0040] Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a diagrammatic view illustrating the main components of one form of apparatus constructed in accordance with the present invention;

FIG. 2 is a flow chart illustrating the main steps in pre-calibrating the apparatus to determine a Transfer Function equating the output of the sound sensor applied to the subject's body with respect to a sound sensor located at a pre-defined distance from the site of sound generation of the subject's body;

FIG. 3 is a block diagram illustrating the main components of an apparatus constructed in accordance with the present invention for using the Transfer Function (TF) for modifying the output of the sensor applied to the subject's body in order to use the currently accepted acoustic activity techniques to determine the existence of a particular physiological condition;

FIG. 4 illustrates the output of a system constructed in accordance with FIG. 3 utilizing a sound sensor located on the subject's body, as compared to one located at a predefined distance from the site of sound generation of the subject's body;

FIG. 5 is a flow chart illustrate a method of determining an Ambient Noise Factor (ANF) in accordance with the present invention for compensating the output of a sound sensor located on the subject's body with respect to the ambient noise conditions existing at the time the examination is made;

FIG. 6 schematically illustrates a system constructed in accordance with the present invention including a microphone type sound sensor, a position or posture sensor, and a motion sensor, all to be located at the same examination site on the subject's body, wherein the above listed elements are housed within a common housing;

FIG. 7 is a block diagram illustrating the use of the

apparatus of FIG. 6 in determining the existence of a particular physiological condition in the subject;

FIG. 8 schematically illustrates a system in accordance with FIG. 8 but modified to enable the system also to be used for calculating an Ambient Noise Factor (ANF) to compensate for noise existing at the time the invention is made;

FIG. 9 is a block diagram illustrating the use of the apparatus of FIG. 8; and

FIG. 10 is a block diagram illustrating the system of FIGs. 8 and 9 but wherein the sound activity provided by the calibration means is derived from the body movement sensor.

[0042] It is to be understood that the foregoing drawings, and the description below, are provided primarily for purposes of facilitating understanding the conceptual aspects of the invention and possible embodiments thereof, including what is presently considered to be a preferred embodiment. In the interest of clarity and brevity, no attempt is made to provide more details than necessary to enable one skilled in the art, using routine skill and design, to understand and practice the described invention. It is to be further understood that the embodiments described are for purposes of example only, and that the invention is capable of being embodied in other forms and applications than described herein.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] FIGs. 1-4 illustrate one preferred embodiment of the invention for examining a subject for a particular physiological condition by monitoring acoustic activity emanating from the subject.

[0044] Thus, FIG. 1 illustrates the subject 2 being examined while lying on a bed 4, e.g. while sleeping. As shown in FIG. 1, a sound sensor SS_1 is located on a particular region of the subject's body, in this case the chest, to produce an output corresponding to the sounds sensed by sensor SS_1. The output of sensor SS_1 is fed to a processor 6 for processing as to be described below.

[0045] FIG. 1 further illustrates a second sensor SS_2 located at a predefined distance from the site of sound generation of the subject's body (as illustrated by the broken arc), e.g. one meter, in accordance with the currently accepted "Gold Standard" technique of analyzing acoustic information.

[0046] Processor 6 processes the outputs simultaneously received from the two sensors SS_1 and SS_2, and produces an output, called a Transfer Function (TF) to be used for equating the output of sound sensor SS_1, applied to the subject's body, with the output that would be produced by the second sensor SS_2, located at a predefined distance from the site of sound generation of the subject's body, as used in the accepted methods of analyzing acoustical information from the subject for a particular physiological condition.

[0047] FIG. 2 is a flow chart illustrating the main steps to produce the Transfer Function (TF). Thus, as shown in FIG. 2, the first sensor SS_1 is located on the patient's body, whereas the second sensor SS_2 is located at a predefined distance (e.g. one meter) from the site of sound generation of the patient's body, as shown by blocks 10 and 11, respectively. The outputs of the two sound sensors SS_1 and SS_2 are simultaneously detected (block 12), and fed to processor 6, which processes the two outputs to determined the Transfer Function (TF) equating the output of sound sensor SS_1 with that of sound sensor SS_2 (block 13).

[0048] Preferably, the two steps indicated by blocks 12 and 13 are repeated a number of times (block 14), such that the processor 6 calculates the average Transfer Function (TF) for use in equating an output of sound sensor SS_1, located on the subject's body, with that which would be detected by sound sensor SS_2 located at a predefined distance from the subject's body.

[0049] It will be possible that in subsequent examinations of the subject, only the first sound sensor, applied to the subject's body, need be used since its output can be modified by the pre-determined Transfer Function (TF) in order to equate that output to one that would be produced by using a sensor located at a predefined distance (one meter) from the site of sound generation of the subject's body.

[0050] In most cases, the first and second sound sensors SS_1, SS_2 would be sound level meters which measure the sound level in decibels. In some applications, however, it may also be desirable to analyze the outputs of the two sound sensors according to other sensed parameters, e.g., their respective frequency spectra.

[0051] In addition, the first sound sensor SS_1, during its initial use for determining the Transfer Function (TF), and its later use during the actual examination of the subject, is attached to the subject's body at a particular region. FIG. 1 illustrates this region as being the chest of the subject. However, many measurement sites may be used, e.g., the supra-sternal notch, the submental region, the upper lip, the sides of the neck. Also, the outputs of the two sensors SS_1 and SS_2 in the pre-calibration stage, or of SS_1 alone in the actual examination stage, may be transmitted to processor 6 in a wired or wireless manner.

[0052] The sound sensors could be omni directional, as well as directional, microphones. They are preferably attached to the body of the subject at the examination site, e.g., by using an adhesive between the sensor and the body, by taping, or by strapping to the body surface.

[0053] FIG. 3 is a schematical block diagram illustrating a system for using a single body-applied sensor SS_1 after being pre-calibrated to determine in Transfer Function TF, for examining acoustic information emanating from the subject to provide information useful for indicating a particular physiological conditional. Thus, FIG. 3 illustrates the sound sensor in the form of microphone 20 to be applied to the body of the subject and for producing an output to be applied to processor 6 (FIG. 1). Processor 6 performs the hardware filtering and process-

ing functions (block 21) and the analog-to-digital conversion function (block 22). Processor 6 modifies the output from A/D converter 22 by the Transfer Function TF, previously determined in accordance with flow chart 2, to equate the output of microphone 20 with the output that would be obtained by a sound sensor (e.g. microphone SS_2, FIG. 1) located at a predefined distance from the site of sound generation of the subject's body, in accordance with current techniques for examining acoustic activity. The output of microphone 20, as modified by the Transfer Function (TF), is then converted to analog information by D/A converter 24, and is displayed as a dB output (block 25).

[0054] FIG. 4 shows the time-course of the acoustic amplitude recorded from the patient's body surface (upper), as compared to the simultaneously recorded acoustic signal recorded by a remote sound recording system (lower). The similarity of the patterns is clearly evident.

[0055] The above described method, for converting sound sensed from the body surface to decibel equivalent values using a pre-calibration Transfer Function, was subsequently validated by comparing predicted decibel values to actually recoded decibel values in a group of 19 patients. The resulting comparisons showed that the mean value of the mean difference in each study was 0.7 dB, with a mean standard deviation of 2dB from the Study standard deviations.

[0056] As explained earlier, a main advantage in the ambulatory milieu is gained by placing the sound sensing system on the patient's body surface, rather than at a distance from the patient, since ambient environmental noise cannot be avoided outside the controlled sleep laboratory environment. Placing the sound sensor on the patient thus helps to improve the ability to distinguish between patient derived sounds and irrelevant environmental sounds, since that at a distance from the site of sound generation of the patient's body, the remote sensor is exposed to sounds from all sources. Thus, the body mounted sound detector may still be affected by environmental noise, whether this occurs directly or through external sounds being conducted through or on the body surface, which noise may vary considerably from one measurement environment to the next. This is particularly important when accurate quantitative measurements are required for standardized evaluations, as for example in the measurement of snoring.

[0057] A further feature of the present invention is therefore, to include a self-calibration means generating a standardized sound signal between the sensor and the patients body surface. This enables the contribution of external noise to be accurately determined, and thus makes it possible to more accurately measure the endogenous sound activity emanating from the patient. This also makes it possible to use different types of microphones in the system, as required to meet the specific needs of the measurement task. The level of ambient noise can be determined by sensing the sound activity with and without the self-calibration TF signal prior to conducting the patient assessment while the device is attached to the patient. By determining the difference in overall acoustic level with and without the previously determined self-calibration TF signal, the level of ambient noise can be determined and can be used for appropriate correction.

[0058] FIG. 5 is a flow diagram illustrating a method of self-calibrating the sound sensor (SS_1) to be placed on the subject's body in order to determine an Ambient Noise Function (ANF) for the respective sensor at the particular time the subject is to be examined for the physiological condition of interest.

[0059] In the flow diagram illustrated in FIG. 5, the Transfer Function (TF) is first determined per the flow diagram of FIG. 2 (block 30). The output of the body-applied sensor SS_1 is sensed (block 31), modified by the Transfer Function TF (block 32); and recorded in the processor 6 (block 33).

[0060] The sound generator (SG) located at the site of sound sensor SS_1 is then actuated (block 34). The output of sensor SS_1 is: sensed while the sound generator is actuated (block 35); modified by the Transfer Function TF (block 36), and recorded in the processor (block 37). The processor then processes the two outputs, one produced before the sound generator was actuated, and the other produced after the sound generator was actuated, in order to determine the Ambient Noise Factors (ANF). The ANF may then be used for correcting the body-applied sensor SS_1 output during a subsequent examination for determining the existence of the particular physiological condition.

[0061] The added sound generator (SG), used for self-calibrating the sound sensor SS_1 for determining the ANC, may take the form of an additional element in the system, such as an appropriately designed sound generating piezoelectric sheet (e.g., Mylar), or an off-the-shelf speaker device of appropriately miniature size.

[0062] As indicated earlier, a particularly important feature of the present invention is that is also enables the body position or posture, as well as body movements, to be sensed and measurement at the time and site the acoustic information is sensed. Such additional information is very useful in determining various physiological conditions, as described above.

[0063] Many sensors are known for sensing body position or posture, and body movement. For example, body position sensors are usually inclination-responsive devices which include an electrically-conductive ball, a quantity of mercury, a bubble, etc., which assume a predetermined position according to its inclination. Motion-responsive devices are usually accelerometer-type devices which produce output signals in accordance with changes in their velocity.

[0064] An alternative method is to use a 3D accelerometer unit to measure the angle of the sensor unit with respect to gravity direction, provided that acceleration of the subject during measurement can be neglected with respect to gravity. Also, two 2D accelerometers can be

used when there is a common dimension being measured twice to determine the sensors position with respect to gravity, or three mutually orthogonal 1D accelerometers. Accelerometers are preferable since they are not inherently limited to recording just a predetermined small set of orientations, but can in fact provide a continuous range of orientations in the three dimensions, and thus provide the time course of the continuous change of orientation during the test.

[0065] Using multi dimension accelerometers as both a body position detector and as a patient movement detector is well known to the art, as disclosed for example in US Patents 5,593,431, 6,477,421 and 7,054,687.

[0066] The separation of position and motion information is based on appropriate filtering of high and low frequency components of the signals. That is, the low-frequency component of the signal is used for determining the body position, and the high-frequency component is used for determining body motion (to help, for example, in identification of the kind of respiratory pattern). Such a sensor may be used for sensing both patient motion and body position.

[0067] FIG. 6 schematically illustrates one form of apparatus constructed in accordance with the present invention utilizing a posture and motion sensor 40 located on the microphone 41 used as the body-applied sound sensor (SS_1, FIG. 1). The relative placement of microphone 41, with respect to posture and motion sensor 40, could be inverted, or these elements could be arranged in a side by side manner. As shown in FIG. 6, the output of microphone 41 is conveyed by cable 42 to processor 43, corresponding to processor 6 in FIG. 1, which processes the information as described above and feeds same via cable 44 to output connector 45.

[0068] FIG. 7 is a block diagram of the overall apparatus illustrating particularly the functions performed by processor 43 in FIG. 6. Thus, as shown in FIG. 7, processor 43 performs the functions of: filtering and processing the received signals (block 46); converting the processed signals to digital form (block 47); determining the Transfer Function TF (block 48); reconverting the latter signal to analog form (block 49); and then producing the various outputs illustrated in FIG. 7, including a posture output 49a, a motion output 49b, and a dB output 49c.

[0069] An important feature of the present invention is that it enables replaying the acoustic, body position, and body movement, information for subsequent analysis and viewing after a study has been conducted.

[0070] In the case of the acoustic information, the actual recorded information can be used, together with any means known to the art, to reproduce the sounds recorded during the actual study, or may be represented as a graphical display depicting the sound magnitude and a representation of the frequency content. As previously mentioned, this information can, among other things, provide relevant information to help understand the condition of the air pathway in the respiratory system, and to define the extent and or location of a specific obstruction in the airway of the respiratory system.

[0071] Likewise, the position information can be displayed in a visual manner in a multitude of ways. One particularly effective method of displaying the body position information would be to utilize the acquired digital information to drive a visual display showing a mannequin in the body positions corresponding to that of the subject during the study. Body surface movement information can also be visually displayed utilizing a variety of methods, including a graphically display depicting the movement magnitude and a representation of the frequency profile or content.

[0072] In all the above, the relevant data, in any combination, can be displayed as a time series, and this will greatly assist in the clinical evaluation of the study. All of the acquired signals may furthermore be represented as outputs in concert with any other data acquired during the study.

[0073] FIG. 8 schematically illustrates apparatus constructed in accordance with the present invention enabling self-calibration of the apparatus for the Ambient Noise Factor (ANF) as described above particularly with reference to the flow chart of FIG. 5. Thus, such an apparatus is basically constructed as in FIG. 6, and therefore the same reference numerals have been used to identify the parts, except that a sound generator SG has been added to the sensors 40 and 41. As described above, particularly with reference to the flow chart of FIG. 5, the sound generator SG is used in order to self-calibrate the sensors 40, 41 for ambient or transient noise by determining the ANF (Ambient Noise Factor) for the particular sensors used, and for the particular ambient conditions at the time the examination is to be made.

[0074] FIG. 9 is a block diagram, corresponding to that of FIG. 7, but also including the sound generator SG. The block diagram is otherwise the same as in FIG. 7, and therefore the same reference numerals have been used to identify corresponding parts, except for the addition of the sound generator SG.

[0075] FIG. 10 illustrates an alternative system that may be used instead of FIG. 9, wherein the sound activity provided by the calibration means is derived from the accelerometer device used for body position and body movement determination.

[0076] Thus, in the system illustrated in FIG. 10, the sound generator SG of FIG. 9 is omitted, and instead, a feedback line 50 is applied from the digital/analog converter 49 for feeding the analog of the output from the processor back to the posture and motion sensor 40.

[0077] The present invention may be used in combination with any known medical device in which the addition of all or some of the measured signals may be of value. The invention may itself also be used as an independent measurement system by being coupled to an appropriate data collection system for utilizing the available data. Multiple devices may be applied at the same time to different body sites to further enhance the recording of useful information. Examples of such beneficial

combination may include the comparison of homologous joints to differentially identify joint problems, the recording of respiratory sound information at different sites to help identify the location of the source of the sound, heart sounds at different locations to help identify the nature of abnormal sounds, etc.

[0078] Therefore, while the invention has been described with respect to several preferred embodiments, it will be appreciated that these are set forth merely for purposes of example, and that many other variations, modifications and applications of the invention may be made.

Claims

1. A method of measuring a particular physiological condition of a subject using sound sensed at a particular region of a subject's body (2), the sound being from a site of sound generation of said subject's body (2), to determine a modified sound sensor output, the method comprising:
   locating a first sound sensor (SS_1) on said particular region of the subject's body (2) to produce an output corresponding to the sounds sensed by said first sound sensor (SS_1);
   characterized by:

   modifying the output of said first sound sensor (SS_1) by a pre-calculated Transfer Function (TF) to equate said output of the first sound sensor (SS_1) to the output (a) of a second sound sensor (SS_2) with respect to which said Transfer Function has been pre-calibrated for the equating, and (b) as said second sound sensor (SS_2) would produce located at a separate location; and
   providing said modified output of said first sound sensor (SS_1) as information for determining the existence of a particular physiological condition;
   wherein the separate location is at a predefined distance remote from said site of sound generation, and the particular region is in close proximity to the site of sound generation.

2. The method according to Claim 1, wherein said Transfer Function (TF) is pre-calculated by:

   locating said first sound sensor (SS_1) on said particular region of the subject's body (2);
   locating said second sound sensor (SS_2) at said predefined distance from the site of sound generation of the subject's body (2) for calibration of said Transfer Function (TF) equating the output of said first sound sensor (SS_1) with that of the second sound sensor (SS_2);
   simultaneously detecting sounds from said site of sound generation sensed by said first and second sound sensors (SS_1, SS_2) to produce outputs corresponding thereto; and processing said outputs of the first and second sound sensors (SS_1, SS_2) to calculate said pre-calculated Transfer Function (TF) for modifying the output of said first sound sensor (SS_1) to equate said sound output to the output of said second sound sensor (SS_2) as said second sensor (SS_2) would produce located at said predefined distance from the site of sound generation of the subject's body (2).

3. The method according to Claim 1, wherein said first and second sound sensors (SS_1, SS_2) are sound level meters which measure the sound level in decibels,
   wherein said first sound sensor (SS_1) is attached to the subject's body (2) at said particular region.

4. The method according to Claim 1, wherein said first sound sensor (SS_1) is pre-calibrated to compensate for ambient noise at the particular time it is used for sensing sound from said site of sound generation to determine said equated sound output as for said predefined distance from the site of sound generation, by

   applying a reference sound generator (SG) to the region of said first sound sensor (SS_1); actuating said reference sound generator (SG) simultaneously with the actuation of said first and second sound sensors (SS_1, SS_2);
   processing the two outputs of said first and second sound sensors (SS_1, SS_2) to determine the difference between the two, which difference represents an Ambient Noise Factor; and
   modifying said calculated Transfer Function (TF) by said Ambient Noise Factor.

5. The method according to Claim 2, wherein said pre-calculated Transfer Function (TF) is further pre-calculated by:

   applying a reference sound generator (SG) to the region of said first sound sensor (SS_1);
   actuating said reference sound generator (SG) simultaneously with the actuation of said first and second sound sensors (SS_1, SS_2);
   processing the two outputs of said first and second sound sensors (SS_1, SS_2) subsequent to said actuation of said reference sound generator (SG) to determine the difference between the two, which difference represents an Ambient Noise Factor; and
   modifying said pre-calculated Transfer Function (TF) by said Ambient Noise Factor.

6. The method according to Claim 5, wherein the posi-

tion of the subject's body (2) at which said first sound sensor (SS_1) is located is also sensed by:

locating a position sensor (40) at said particular region of the subject's body (2); and
producing an output which is also provided as information for measuring said particular physiological condition.

7. The method according to Claim 6, wherein motion of the subject's body (2) is also sensed by:

locating a motion sensor (40) at said particular region of the subject's body (2), and
producing an output which is also provided as information for measuring said particular physiological condition.

8. Apparatus for measuring a particular physiological condition of a subject by using sound sensed at a particular region of a subject's body (2), the sound being from a site of sound generation of a subject's body (2), to determine a modified parameter of sound sensor output, the apparatus comprising:

a first sound sensor (SS_1) constructed to be located at and attachable to said particular region of the subject's body (2) to produce an output corresponding to the sounds sensed by said first sound sensor (SS_1); and
a second sound sensor (SS_2) constructed to be located at said separate location, and to produce an output corresponding to the sounds sensed by said second sound sensor (SS_2);

characterized by:

a processor (6) effective to receive simultaneously the outputs of said first and second sound sensors (SS_1, SS_2), to calculate therefrom a Transfer Function (TF) for modifying the output of said first sound sensor (SS_1) to equate to the output of said second sound sensor (SS_2) as said second sound sensor (SS_2) would produce located at said separate location, to utilize said Transfer Function (TF) as a pre-calculated Transfer Function for so-modifying subsequent output of said first sound sensor (SS_1), and to utilize said modified subsequent output of said first sound sensor (SS_1) for measuring said particular physiological condition;
wherein the separate location is at a predefined distance remote from said site of sound generation, and the particular region is in close proximity to the site of sound generation.

9. The apparatus according to Claim 8, wherein: said apparatus also includes at least one of:

a position sensor (40) constructed so as also to be attachable to said particular region of the subject's body (2), and said processor (6) is also effective to utilize the output of said position sensor (40) for producing information useful in determining said particular physiological condition; and
a motion sensor (40) constructed so as also to be attachable to said particular region of the subject's body (2), and said processor (6) is also effective to utilize the output of said motion sensor (40) for producing information useful in determining said particular physiological condition.

10. The apparatus according to Claim 9, wherein said apparatus also includes a reference sound generator (SG) also attachable to the subject's body (2) at said particular region, to generate reference sounds for use in determining an Ambient Noise Factor to be used for pre-calibrating the apparatus for the ambient noise at the time the output of said first sound sensor (SS_1) is used for producing information useful in determining the existence of said particular physiological condition.

11. The apparatus according to Claim 10, wherein some or all of said first sound sensor (SS_1), said position sensor (40), said motion sensor (40), and said reference sound generator (SG), are housed within a common housing.

12. The apparatus according to Claim 11, further including means for replaying the acoustic body position and body movement information for subsequent analysis and for viewing after a study has been conducted.

13. The apparatus according to Claim 11, wherein said particular physiological condition is selected from the group consisting of:

a snoring or a breathing disorder,
blood pressure,
a heart valve closure condition, or other cardiovascular condition of the subject,
a joint disorder of the subject detected by measuring a joint movement related to sound patterns,
a condition related to the gastrointestinal system of the subject.

14. The apparatus according to claim 9, wherein said motion sensor (40) comprises an accelerometer, and the accelerometer is operable to generate sound activity for use as reference sounds in determining an Ambient Noise Factor to be used for pre-calibrating the apparatus for the ambient noise at the time the output of said first sound sensor (SS_1) is used

for producing information useful in determining the existence of said particular physiological condition.

15. The apparatus according to claim 9, wherein said position sensor (40) comprises an accelerometer, and the accelerometer is operable to generate sound activity for use as reference sounds in determining an Ambient Noise Factor to be used for pre-calibrating the apparatus for the ambient noise at the time the output of said first sound sensor (SS_1) is used for producing information useful in determining the existence of said particular physiological condition.

Patentansprüche

1. Verfahren zum Messen eines speziellen physiologischen Zustands einer Person unter Verwendung eines in einem speziellen Bereich des Körpers (2) einer Person erfassten Schalls, wobei der Schall von einem Ort der Schallerzeugung des Körpers (2) der Person stammt, um eine modifizierte Schallsensorausgabe zu bestimmen, wobei das Verfahren umfasst:
Anordnen eines ersten Schallsensors (SS_1) an dem speziellen Bereich des Körpers (2) der Person, um eine Ausgabe zu erzeugen, die den von dem ersten Schallsensor (SS_1) erfassten Schällen entspricht;
gekennzeichnet durch:

Modifizieren der Ausgabe des ersten Schallsensors (SS_1) durch eine vorausberechnete Übertragungsfunktion (TF), um die Ausgabe des ersten Schallsensors (SS_1) mit der Ausgabe (a) eines zweiten Schallsensors (SS_2) gleichzusetzen, in Bezug auf den die Übertragungsfunktion für das Gleichsetzen vorkalibriert wurde, und (b) wie sie der zweite Schallsensor (SS_2) erzeugen würde, der an einer getrennten Stelle angeordnet ist; und
Bereitstellen der modifizierten Ausgabe des ersten Schallsensors (SS_1) als Information zum Bestimmen des Vorhandenseins eines speziellen physiologischen Zustands;
wobei die getrennte Stelle in einer vordefinierten Entfernung entfernt von dem Ort der Schallerzeugung liegt und der spezielle Bereich in unmittelbarer Nähe zu dem Ort der Schallerzeugung liegt.

2. Verfahren nach Anspruch 1, wobei die Übertragungsfunktion (TF) vorausberechnet wird durch:

Anordnen des ersten Schallsensors (SS_1) an dem speziellen Bereich des Körpers (2) der Person;
Anordnen des zweiten Schallsensors (SS_2) in der vordefinierten Entfernung von der Stelle der Schallerzeugung des Körpers (2) der Person für die Kalibrierung der Übertragungsfunktion (TF), die die Ausgabe des ersten Schallsensors (SS_1) mit jener des zweiten Schallsensors (SS_2) gleichsetzt;
simultanes Detektieren von Schällen von dem Ort der Schallerzeugung, die von dem ersten und dem zweiten Schallsensor (SS_1, SS_2) erfasst werden, um Ausgaben zu erzeugen, die diesen entsprechen; und
Verarbeiten der Ausgaben der ersten und zweiten Schallsensoren (SS_1, SS_2), um die vorausberechnete Übertragungsfunktion (TF) zum Modifizieren der Ausgabe des ersten Schallsensors (SS_1) zu berechnen, um die Schallausgabe mit der Ausgabe des zweiten Schallsensors (SS_2) gleichzusetzen, wie sie der zweite Sensor (SS_2), der sich in der vordefinierten Entfernung von dem Ort der Schallerzeugung des Körpers (2) der Person befindet, erzeugen würde.

3. Verfahren nach Anspruch 1, wobei der erste und der zweite Schallsensor (SS_1, SS_2) Schallpegelmesser sind, die den Schallpegel in Dezibel messen,
wobei der erste Schallsensor (SS_1) an dem Körper (2) der Person in dem speziellen Bereich befestigt ist.

4. Verfahren nach Anspruch 1, wobei der erste Schallsensor (SS_1) vorkalibriert ist, um Umgebungsgeräusche zu dem speziellen Zeitpunkt zu kompensieren, zu dem er zum Erfassen von Schall von dem Schallerzeugungsort verwendet wird, um die gleichgesetzte Schallausgabe wie für die vordefinierte Entfernung vom Ort der Schallerzeugung zu bestimmen, durch

Anwenden eines Referenzschallgenerators (SG) auf den Bereich des ersten Schallsensors (SS_1);
Betätigen des Referenzschallgenerators (SG) gleichzeitig mit der Betätigung des ersten und des zweiten Schallsensors (SS_1, SS_2);
Verarbeitung der zwei Ausgaben des ersten und des zweiten Schallsensors (SS_1, SS_2), um die Differenz zwischen den beiden zu bestimmen, wobei die Differenz einen Umgebungsrauschfaktor darstellt; und
Modifizieren der berechneten Übertragungsfunktion (TF) durch den Umgebungsrauschfaktor.

5. Verfahren nach Anspruch 2, wobei die vorausberechnete Übertragungsfunktion (TF) weiter vorausberechnet wird durch:

Anwenden eines Referenzschallgenerators (SG) auf den Bereich des ersten Schallsensors

(SS_1);
Betätigen des Referenzschallgenerators (SG) gleichzeitig mit der Betätigung des ersten und des zweiten Schallsensors (SS_1, SS_2);
Verarbeiten der zwei Ausgaben des ersten und des zweiten Schallsensors (SS_1, SS_2) im Anschluss an die Betätigung des Referenzschallgenerators (SG), um die Differenz zwischen den beiden zu bestimmen, wobei die Differenz einen Umgebungsrauschfaktor darstellt; und
Modifizieren der vorausberechneten Übertragungsfunktion (TF) durch den Umgebungsrauschfaktor.

6. Verfahren nach Anspruch 5, wobei die Position des Körpers (2) der Person, an der sich der erste Schallsensor (SS_1) befindet, ebenfalls erfasst wird durch:

Anordnen eines Positionssensors (40) in dem speziellen Bereich des Körpers (2) der Person; und
Erzeugen einer Ausgabe, die auch als Information zum Messen des speziellen physiologischen Zustands bereitgestellt wird.

7. Verfahren nach Anspruch 6, wobei die Bewegung des Körpers (2) der Person ebenfalls erfasst wird durch:

Anordnen eines Bewegungssensors (40) in dem speziellen Bereich des Körpers (2) der Person, und
Erzeugen einer Ausgabe, die auch als Information zum Messen des speziellen physiologischen Zustands bereitgestellt wird.

8. Vorrichtung zum Messen eines speziellen physiologischen Zustands einer Person unter Verwendung eines in einem speziellen Bereich des Körpers (2) einer Person erfassten Schalls, wobei der Schall von einem Ort der Schallerzeugung des Körpers (2) der Person stammt, um einen modifizierten Parameter der Schallsensorausgabe zu bestimmen, wobei die Vorrichtung umfasst:

einen ersten Schallsensor (SS_1), der ausgebildet ist, um in dem speziellen Bereich des Körpers (2) der Person angeordnet und daran befestigt zu sein, um eine Ausgabe zu erzeugen, die den von dem ersten Schallsensor (SS_1) erfassten Schällen entspricht; und
einen zweiten Schallsensor (SS_2), der ausgebildet ist, um an der getrennten Stelle angeordnet zu sein, um eine Ausgabe zu erzeugen, die den von dem zweiten Schallsensor (SS_2) erfassten Schällen entspricht;
gekennzeichnet durch:

einen Prozessor (6), der zum gleichzeitigen Empfangen der Ausgaben des ersten und des zweiten Schallsensors (SS_1, SS_2) wirksam ist, um daraus eine Übertragungsfunktion (TF) zu berechnen zum Modifizieren des Ausgangssignals des ersten Schallsensors (SS_1), um die Ausgabe des zweiten Schallsensors (SS_2) gleichzusetzen, wie sie der zweite Schallsensor (SS_2) erzeugen würde, der an der getrennten Stelle angeordnet ist, um die Übertragungsfunktion (TF) als vorausberechnete Übertragungsfunktion zu verwenden, um so eine nachfolgende Ausgabe des ersten Schallsensors (SS_1) zu modifizieren und die modifizierte nachfolgende Ausgabe des ersten Schallsensors (SS_1) zum Messen des speziellen physiologischen Zustands zu verwenden;
wobei die getrennte Stelle in einer vordefinierten Entfernung entfernt von dem Ort der Schallerzeugung liegt und der spezielle Bereich in unmittelbarer Nähe zu dem Ort der Schallerzeugung liegt.

9. Vorrichtung nach Anspruch 8, wobei: die Vorrichtung auch mindestens eines umfasst von:

einem Positionssensor (40), der so ausgestaltet ist, dass er auch an dem speziellen Bereich des Körpers (2) der Person befestigbar ist, und der Prozessor (6) auch wirksam ist, um die Ausgabe des Positionssensors (40) zum Erzeugen nützlicher Informationen beim Bestimmen des speziellen physiologischen Zustands zu verwenden; und
einem Bewegungssensor (40), der so ausgestaltet ist, dass er auch an dem speziellen Bereich des Körpers (2) der Person befestigbar ist, und der Prozessor (6) auch wirksam ist, um die Ausgabe des Bewegungssensors (40) zum Erzeugen nützlicher Informationen beim Bestimmen des speziellen physiologischen Zustands zu verwenden.

10. Vorrichtung nach Anspruch 9, wobei die Vorrichtung auch einen Referenzschallgenerator (SG) umfasst, der auch an dem Körper (2) der Person in dem speziellen Bereich befestigbar ist, um Referenzschälle zur Verwendung bei der Bestimmung eines Umgebungsrauschfaktors zu erzeugen, der für die Vorkalibrierung der Vorrichtung für das Umgebungsrauschen zu dem Zeitpunkt verwendet wird, zu dem die Ausgabe des ersten Schallsensors (SS_1) zum Erzeugen nützlicher Informationen beim Bestimmen der Existenz des speziellen physiologischen Zustands verwendet wird.

11. Vorrichtung nach Anspruch 10, wobei einige oder

alle des ersten Schallsensors (SS_1), des Positionssensors (40), des Bewegungssensors (40) und des Referenzschallgenerators (SG) in einem gemeinsamen Gehäuse untergebracht sind.

12. Vorrichtung nach Anspruch 11, ferner umfassend Mittel zum Wiedergeben der akustischen Körperpositions- und Körperbewegungsinformation für die nachfolgende Analyse und zum Betrachten, nachdem eine Untersuchung durchgeführt wurde.

13. Vorrichtung nach Anspruch 11, wobei der spezielle physiologische Zustand ausgewählt ist aus der Gruppe bestehend aus:

einem Schnarchen oder einer Atmungsstörung, Blutdruck,
einem Herzklappenverschlusszustand oder einem anderen kardiovaskulären Zustand der Person,
einer Gelenkstörung der Person, die durch Messen einer Gelenkbewegung im Zusammenhang mit Schallmustern detektiert wird,
einem Zustand, der mit dem Magen-Darm-System der Person zusammenhängt.

14. Vorrichtung nach Anspruch 9, wobei der Bewegungssensor (40) einen Beschleunigungsmesser umfasst und der Beschleunigungsmesser betätigbar ist, um eine Schallaktivität zur Verwendung als Referenzschälle bei der Bestimmung eines Umgebungsrauschfaktors zu erzeugen, der für die Vorkalibrierung der Vorrichtung für das Umgebungsrauschen zu dem Zeitpunkt verwendet wird, zu dem die Ausgabe des ersten Schallsensors (SS_1) zum Erzeugen nützlicher Informationen beim Bestimmen der Existenz des speziellen physiologischen Zustands verwendet wird.

15. Vorrichtung nach Anspruch 9, wobei der Positionssensor (40) einen Beschleunigungsmesser umfasst und der Beschleunigungsmesser betätigbar ist, um eine Schallaktivität zur Verwendung als Referenzschälle bei der Bestimmung eines Umgebungsrauschfaktors zu erzeugen, der für die Vorkalibrierung der Vorrichtung für das Umgebungsrauschen zu dem Zeitpunkt verwendet wird, zu dem die Ausgabe des ersten Schallsensors (SS_1) zum Erzeugen nützlicher Informationen beim Bestimmen der Existenz des speziellen physiologischen Zustands verwendet wird.

Revendications

1. Procédé de mesure d'une condition physiologique particulière d'un sujet à l'aide d'un son détecté dans une région particulière du corps (2) d'un sujet, le son provenant d'un site de génération de son dudit corps (2) du sujet afin de déterminer une sortie de capteur de son modifiée, le procédé comprenant :

la localisation d'un premier capteur de son (SS_1) sur ladite région particulière du corps du sujet (2) pour produire une sortie correspondant aux sons détectés par ledit premier capteur de son (SS_1) ;
caractérisé par :

la modification de la sortie dudit premier capteur de son (SS_1) par une fonction de transfert (TF) pré-calculée pour assimiler ladite sortie du premier capteur de son (SS_1) à la sortie (a) d'un second capteur de son (SS_2) par rapport à laquelle ladite fonction de transfert a été pré-étalonnée pour l'assimilation et (b) telle que ledit second capteur de son (SS_2) produirait s'il était situé à un endroit distinct ; et
la fourniture de ladite sortie modifiée dudit premier capteur de son (SS_1) sous forme d'informations pour déterminer l'existence d'une condition physiologique particulière ; dans lequel l'endroit distinct se trouve à une distance prédéfinie éloignée dudit site de génération de son et la région particulière est à proximité étroite du site de génération de son.

2. Procédé selon la revendication 1, dans lequel ladite fonction de transfert (TF) est pré-calculée par :

localisation dudit premier capteur de son (SS_1) sur ladite région particulière du corps du sujet (2) ;
localisation dudit second capteur de son (SS_2) à ladite distance prédéfinie du site de génération de son du corps (2) du sujet pour l'étalonnage de ladite fonction de transfert (TF) en assimilant la sortie dudit premier capteur de son (SS_1) à celle du second capteur de son (SS_2) ;
détection simultanée des sons provenant dudit site de génération de son détectés par lesdits premier et second capteurs de son (SS_1, SS_2) pour produire des sorties correspondant à ceux-ci ; et
traitement desdites sorties des premier et second capteurs de son (SS_1, SS_2) pour calculer ladite fonction de transfert (TF) pré-calculée afin de modifier la sortie dudit premier capteur de son (SS_1) afin d'assimiler ladite sortie de son à la sortie dudit second capteur de son (SS_2) telle que ledit second capteur (SS_2) produirait s'il était situé à ladite distance prédéfinie du site de génération de son du corps (2) du sujet.

3. Procédé selon la revendication 1, dans lequel lesdits premier et second capteurs de son (SS_1, SS_2) sont des sonomètres qui mesurent le niveau sonore en décibels,
dans lequel ledit premier capteur de son (SS_1) est attaché au corps du sujet (2) au niveau de ladite région particulière.

4. Procédé selon la revendication 1, dans lequel ledit premier capteur de son (SS_1) est pré-étalonné pour compenser le bruit ambiant au moment particulier où il est utilisé pour détecter le son provenant dudit site de génération de son afin de déterminer ladite sortie de son équivalente comme pour ladite distance prédéfinie depuis le site de génération sonore, par

application d'un générateur de sons de référence (SG) à la région dudit premier capteur de son (SS_1) ;
actionnement dudit générateur de sons de référence (SG) simultanément avec l'actionnement desdits premier et second capteurs de son (SS_1, SS_2) ;
traitement des deux sorties desdits premier et second capteurs de son (SS_1, SS_2) pour déterminer la différence entre les deux, laquelle différence représente un facteur de bruit ambiant ; et
modification de ladite fonction de transfert (TF) calculée par ledit facteur de bruit ambiant.

5. Procédé selon la revendication 2, dans lequel ladite fonction de transfert (TF) pré-calculée est en outre pré-calculée par :

application d'un générateur de sons de référence (SG) à la région dudit premier capteur de son (SS_1) ;
actionnement dudit générateur de sons de référence (SG) simultanément avec l'actionnement desdits premier et second capteurs de son (SS_1, SS_2) ;
traitement des deux sorties desdits premier et second capteurs de son (SS_1, SS_2) à la suite dudit actionnement dudit générateur de sons de référence (SG) pour déterminer la différence entre les deux, laquelle différence représente un facteur de bruit ambiant ; et
modification de ladite fonction de transfert (TF) pré-calculée par ledit facteur de bruit ambiant.

6. Procédé selon la revendication 5, dans lequel la position du corps (2) du sujet à laquelle est situé ledit premier capteur de son (SS_1) est également détectée par :

localisation d'un capteur de position (40) au niveau de ladite région particulière du corps du sujet (2) ; et
production d'une sortie qui est également fournie sous forme d'informations pour mesurer ladite condition physiologique particulière.

7. Procédé selon la revendication 6, dans lequel le mouvement du corps (2) du sujet est également détecté par :

localisation d'un capteur de mouvement (40) au niveau de ladite région particulière du corps du sujet (2) ; et
production d'une sortie qui est également fournie sous forme d'informations pour mesurer ladite condition physiologique particulière.

8. Appareil de mesure d'une condition physiologique particulière d'un sujet en utilisant un son détecté au niveau d'une région particulière du corps (2) d'un sujet, le son provenant d'un site de génération de son du corps (2) d'un sujet, afin de déterminer un paramètre modifié d'une sortie de capteur de son, l'appareil comprenant :

un premier capteur de son (SS_1) conçu pour être situé et pouvoir être attaché au niveau de ladite région particulière du corps (2) du sujet pour produire une sortie correspondant aux sons détectés par ledit premier capteur de son (SS_1) ; et
un second capteur de son (SS_2) conçu pour être situé au niveau dudit emplacement distinct et pour produire une sortie correspondant aux sons détectés par ledit second capteur de son (SS_2) ;
caractérisé par :

un processeur (6) efficace pour recevoir simultanément les sorties desdits premier et second capteurs de son (SS_1, SS_2), pour calculer à partir de celles-ci une fonction de transfert (TF) pour modifier
la sortie dudit premier capteur de son (SS_1) pour assimilation à la sortie dudit second capteur de son (SS_2) telle que ledit second capteur de son (SS_2) produirait s'il était situé au niveau dudit emplacement séparé, pour utiliser ladite fonction de transfert (TF) en tant que fonction de transfert pré-calculée pour modifier ainsi la sortie suivante dudit premier capteur de son (SS_1) et pour utiliser ladite sortie suivante modifiée dudit premier capteur de son (SS_1) pour mesurer ladite condition physiologique particulière ;
dans lequel l'endroit distinct se trouve à une distance prédéfinie éloignée dudit site de génération de son et la région particulière est à proximité étroite du site de génération de son.

9. Appareil selon la revendication 8, dans lequel : ledit appareil comprend également au moins un élément parmi :

un capteur de position (40) conçu de manière également à pouvoir être attaché à ladite région particulière du corps du sujet (2) et ledit processeur (6) est également efficace pour utiliser la sortie dudit capteur de position (40) pour produire des informations utiles dans la détermination de ladite condition physiologique particulière ; et
un capteur de mouvement (40) conçu également de manière à pouvoir être attaché à ladite région particulière du corps (2) du sujet et ledit processeur (6) est également efficace pour utiliser la sortie dudit capteur de mouvement (40) afin de produire des informations utiles dans la détermination de ladite condition physiologique particulière.

10. Appareil selon la revendication 9, dans lequel ledit appareil comprend également un générateur de sons de référence (SG) pouvant également être attaché au corps (2) du sujet au niveau de ladite région particulière, afin de générer des sons de référence à utiliser pour déterminer un facteur de bruit ambiant devant être utilisé pour pré-étalonner l'appareil pour le bruit ambiant au moment où la sortie dudit premier capteur de son (SS_1) est utilisée pour produire des informations utiles pour déterminer l'existence de ladite condition physiologique particulière.

11. Appareil selon la revendication 10, dans lequel tout ou partie dudit premier capteur de son (SS_1), dudit capteur de position (40), dudit capteur de mouvement (40) et dudit générateur de sons de référence (SG) sont logés dans un boîtier commun.

12. Appareil selon la revendication 11, comprenant en outre des moyens pour rejouer la position du corps acoustique et les informations de mouvement du corps pour une analyse ultérieure et pour la visualisation après qu'une étude a été effectuée.

13. Appareil selon la revendication 11, dans lequel ladite condition physiologique particulière est choisie dans le groupe constitué de :

un ronflement ou un trouble respiratoire,
la tension artérielle,
une condition de fermeture de la valve cardiaque ou autre condition cardio-vasculaire du sujet,
un trouble articulaire du sujet détecté par la mesure d'un mouvement articulaire lié à des structures sonores,
une condition liée au système gastro-intestinal du sujet.

14. Appareil selon la revendication 9, dans lequel ledit capteur de mouvement (40) comprend un accéléromètre et l'accéléromètre peut fonctionner pour générer une activité sonore à utiliser comme sons de référence pour déterminer un facteur de bruit ambiant à utiliser pour pré-étalonner l'appareil pour le bruit ambiant au moment où la sortie dudit premier capteur de son (SS_1) est utilisée pour produire des informations utiles pour déterminer l'existence de ladite condition physiologique particulière.

15. Appareil selon la revendication 9, dans lequel ledit capteur de position (40) comprend un accéléromètre et l'accéléromètre peut fonctionner pour générer une activité sonore à utiliser comme sons de référence pour déterminer un facteur de bruit ambiant à utiliser pour pré-étalonner l'appareil pour le bruit ambiant au moment où la sortie dudit premier capteur de son (SS_1) est utilisée pour produire des informations utiles pour déterminer l'existence de ladite condition physiologique particulière.

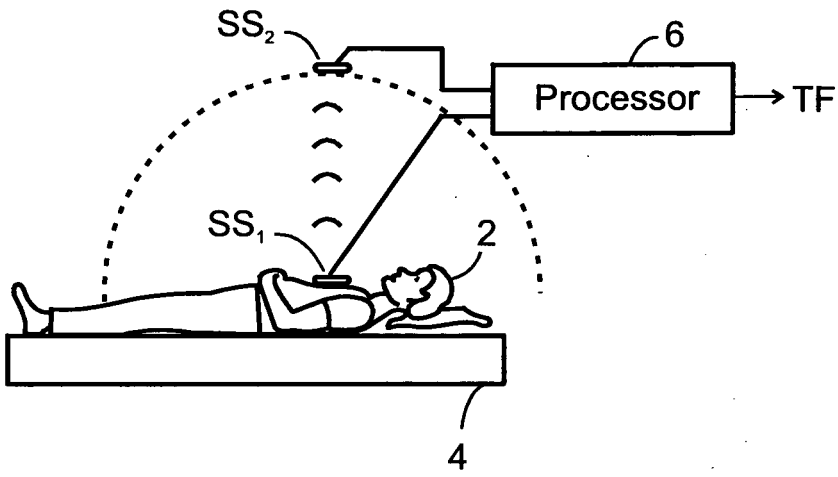
SS2
6
Processor
TF
SS1
2
4

FIG. 1

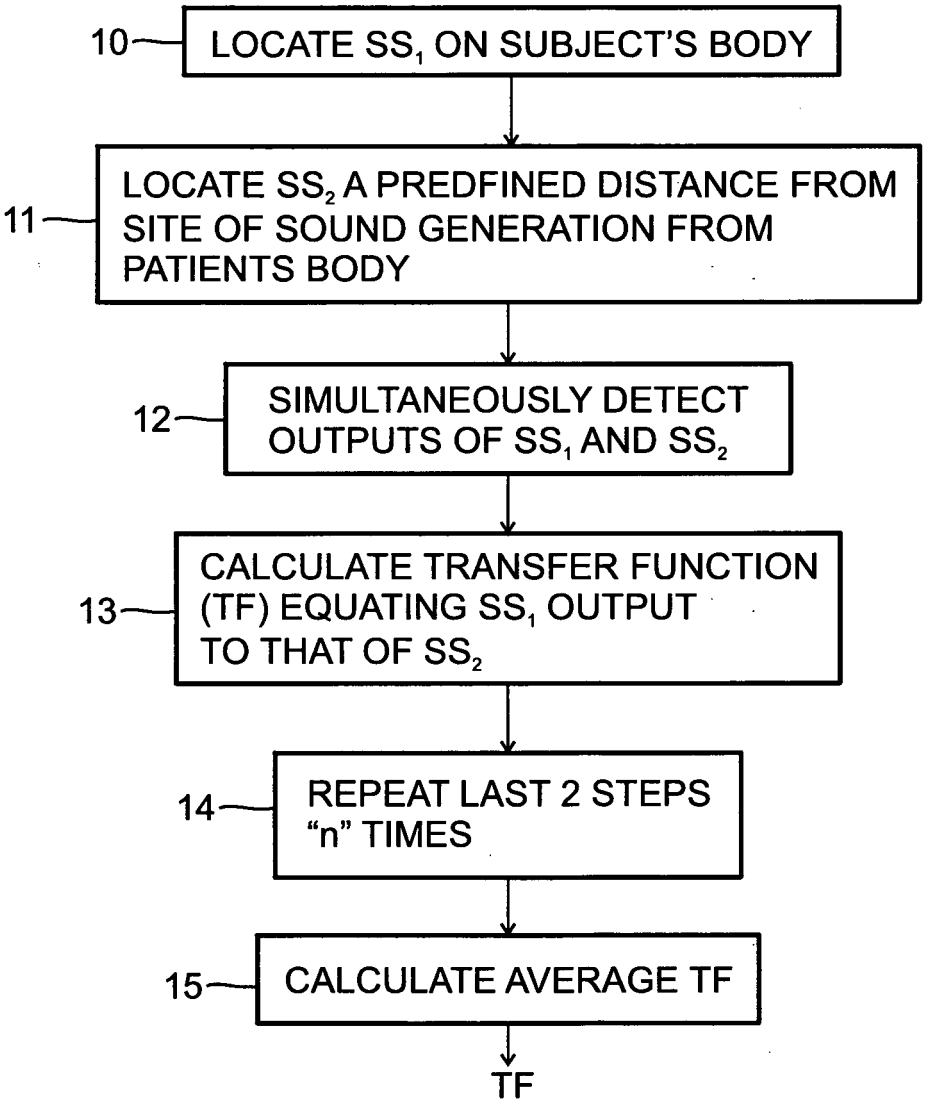
10
LOCATE SS1 ON SUBJECT'S BODY
11
LOCATE SS2 A PREDFINED DISTANCE FROM SITE OF SOUND GENERATION FROM PATIENTS BODY
12
SIMULTANEOUSLY DETECT OUTPUTS OF SS1 AND SS2
13
CALCULATE TRANSFER FUNCTION (TF) EQUATING SS1 OUTPUT TO THAT OF SS2
14
REPEAT LAST 2 STEPS "n" TIMES
15
CALCULATE AVERAGE TF
TF

FIG. 2

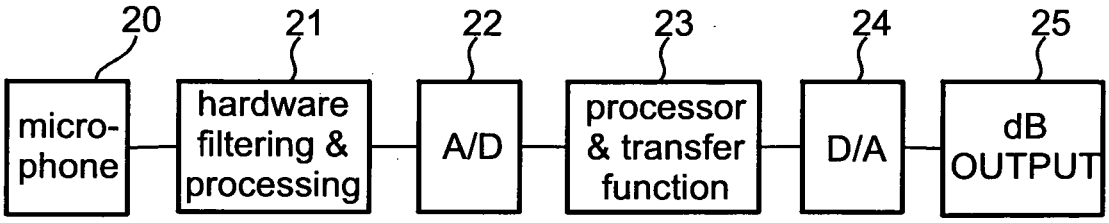
20
21
22
23
24
25
micro-phone
hardware filtering & processing
A/D
processor & transfer function
D/A
dB OUTPUT

FIG. 3

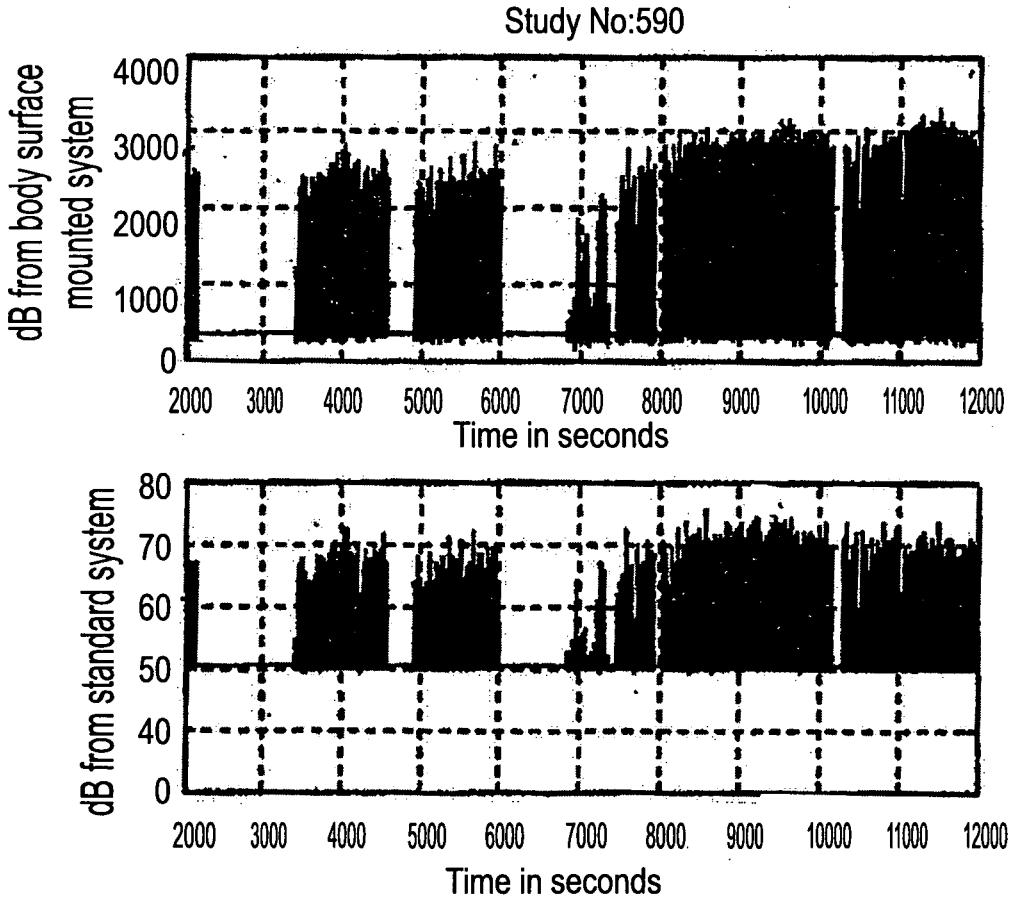
Study No:590
dB from body surface mounted system
4000
3000
2000
1000
0
2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000
Time in seconds
dB from standard system
80
70
60
50
40
0
2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000
Time in seconds

FIG. 4

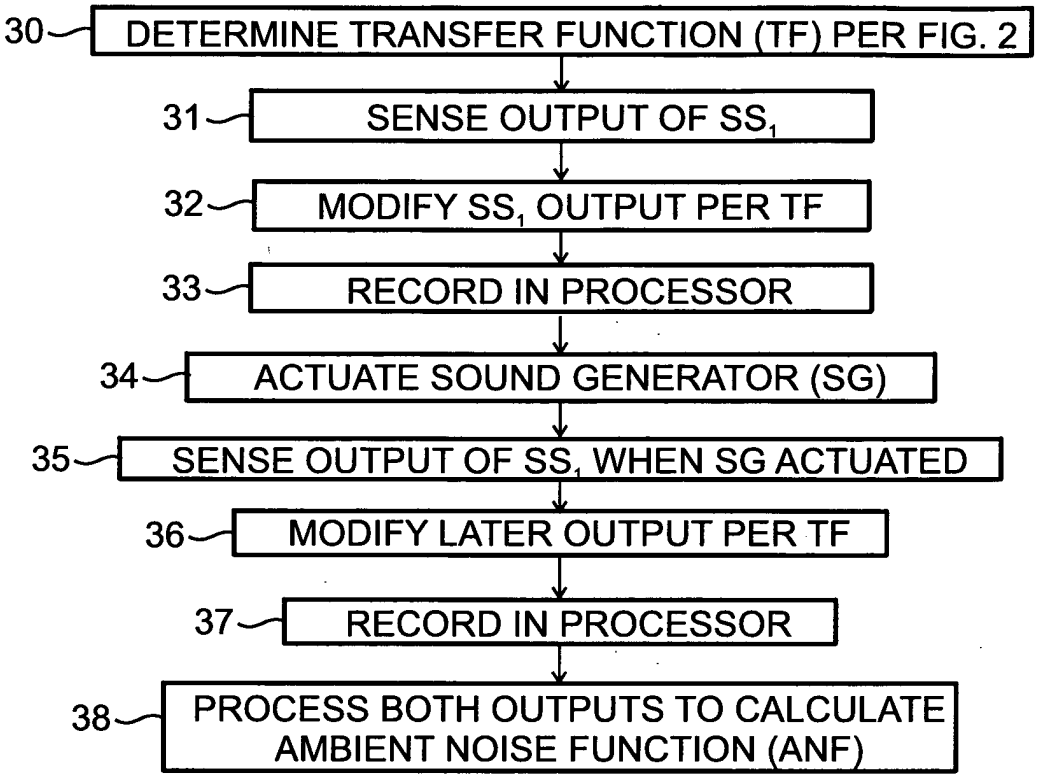

FIG. 5

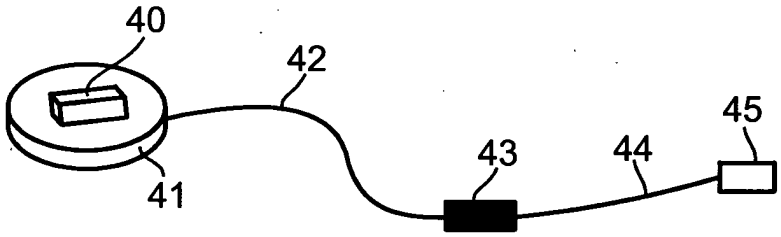

FIG. 6

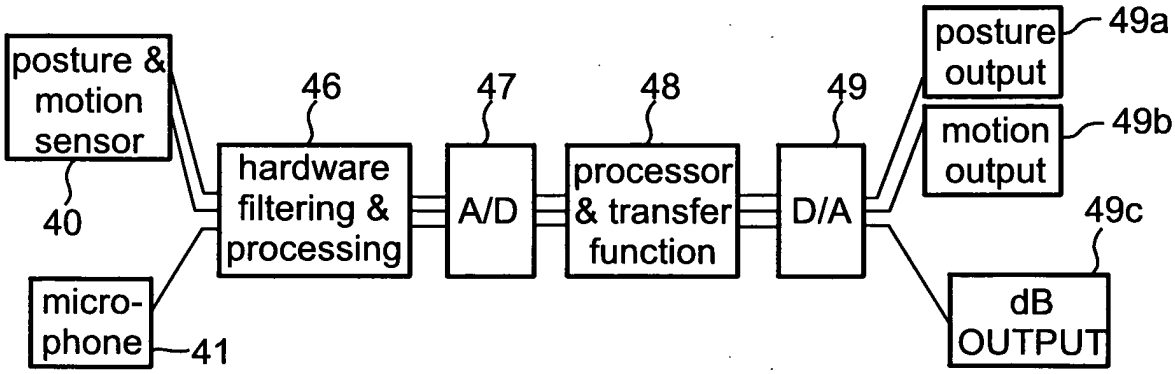

FIG. 7

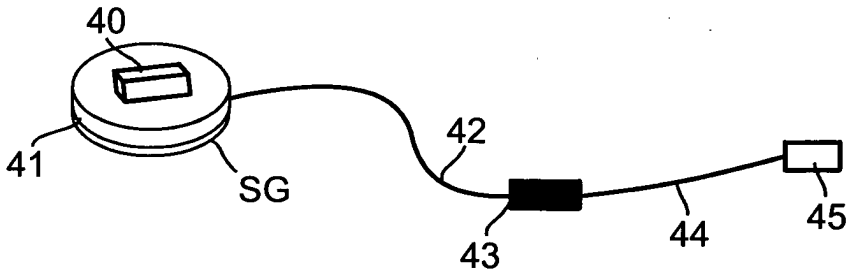

FIG. 8

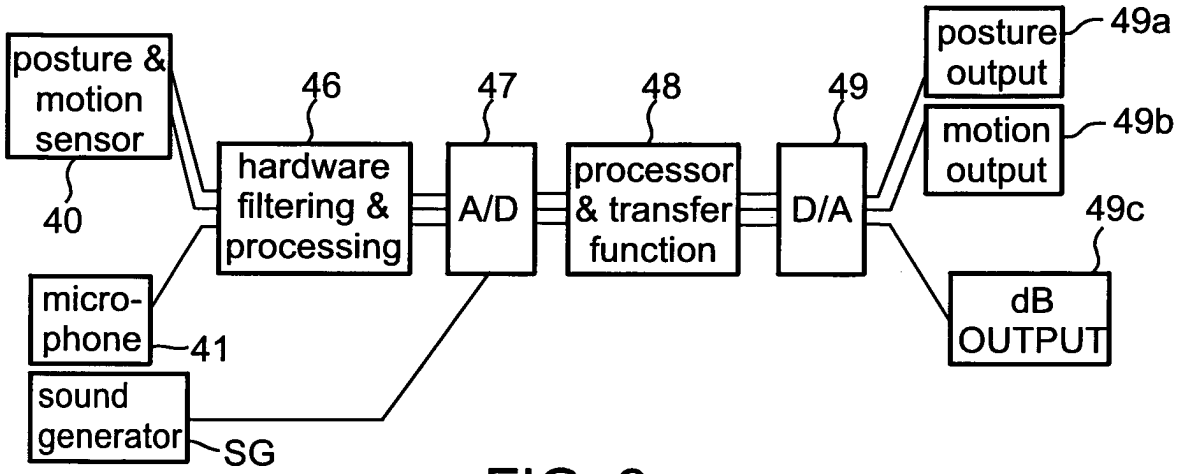

FIG. 9

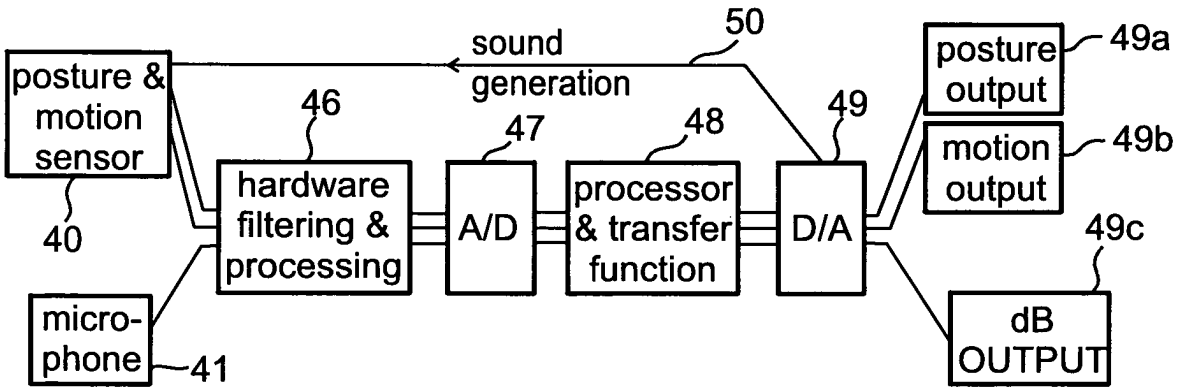

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	利用声学信息检查受试者特定生理状况的方法和装置		
公开(公告)号	EP2280639B1	公开(公告)日	2018-07-04
申请号	EP2009754340	申请日	2009-05-26
申请(专利权)人(译)	伊塔马尔MEDICAL LTD.		
当前申请(专利权)人(译)	伊塔马尔MEDICAL LTD.		
[标]发明人	HERSCOVICI COHEN SARAH SCHNALL ROBERT P		
发明人	HERSCOVICI-COHEN, SARAH SCHNALL, ROBERT P.		
IPC分类号	A61B5/00		
CPC分类号	A61B5/08 A61B5/4806 A61B7/003 A61B2560/0223		
代理机构(译)	丹麦美国律师协会		
优先权	61/071992 2008-05-29 US		
其他公开文献	EP2280639A4 EP2280639A2		
外部链接	Espacenet		

摘要(译)

一种用于根据一种技术检查对象的特定生理状况的方法和设备，该技术利用由对象产生的声音并且通过定位第一声音传感器（例如，a）来在距对象的声音产生的位置预定距离处感测到的声音。声级计，其测量在受试者身体的特定区域上以分贝为单位的声级，以产生对应于由此感测到的声级的输出;通过预先计算的传递函数修改第一声级计的输出，该传递函数将其输出等同于位于距受试者身体的声音产生位置预定距离处的第二声级计的输出;并利用第一声级计的修改输出来确定特定生理状况的存在。

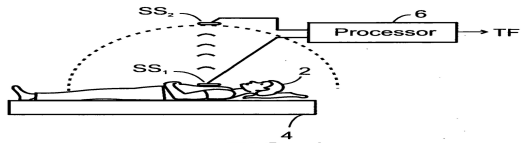

FIG. 1

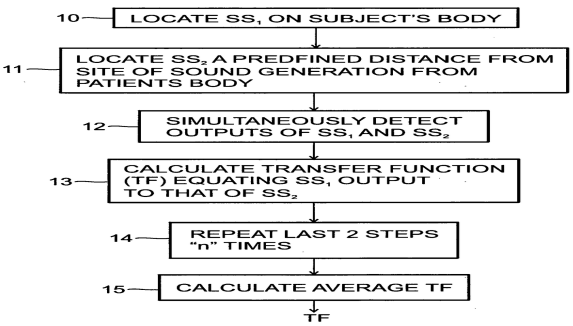

FIG. 2