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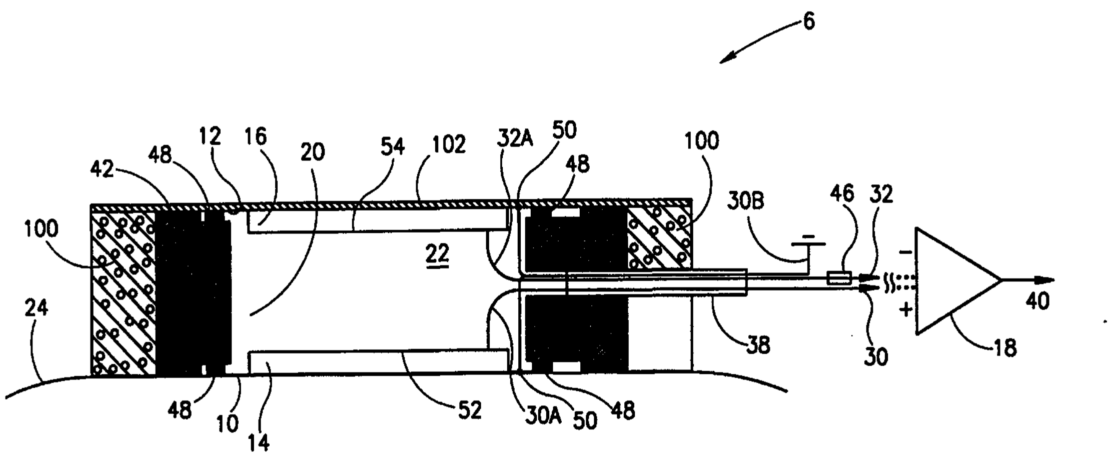

(57) Abstract

A device for detecting sounds generated within a body including (1) a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and (2) airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

SENSOR FOR BODY SOUNDS

FIELD OF THE INVENTION

The present invention relates generally to sensors, and specifically to systems suitable for use in body sounds detection and analysis.

BACKGROUND OF THE INVENTION

The art of listening to body sounds, or auscultation, has been used by physicians for thousands of years, for diagnosing various diseases.

Auscultation was initially performed by placing the physician's ear directly on the skin of the patient. At the beginning of the 19th century, R.T. Laennec introduced a tool, the stethoscope, for transmitting of body sounds to the ear.

Currently used stethoscopes include a "chest piece" brought into contact with the patient's skin, and two flexible tubes, terminating in the physician's ears.

The use of various sensors which transform the shocks and vibrations produced by body sounds into electrical voltages is well known in the art. Various types of transducers have been used in implementing body sound sensors, including both air coupled and contact microphones or accelerometers.

Swedish patent 8702647-2 to Hök describes a contact microphone in which the vibrations of the body surface induce deformations of a piezoelectric transducer. Contact sensors using such a piezoelectric element are sensitive to electromagnetic noise caused by nearby AC power lines, by static electricity discharges or by nearby electric devices.

In general, sound detecting devices are made to reject shocks and vibrations induced by structure-borne sounds and detect induced by airborne sounds. Devices also exist which are made immune to airborne isotropic sound.

A sensor which detects only relative vibrations while rejecting non relative ones is described in US patent 5,456,116 to Lew. The sensor uses a piezoelectric transducer and a mechanical structure to differentiate the vibrations to be detected from those to be rejected.

US patent 5,335,282 to Cardas, describes a microphone for air conducted sound in which two or more transducers perform simultaneous measurements. Transducer outputs are summed such as to make this device substantially immune to shock and vibration.

Driving a transducer from opposite directions by airborne sounds has also been used to cancel noise. An example of such a device is an aircraft radio noise canceling microphone in which a transducer, driven from opposite directions substantially cancels airborne noise while not affecting directional sound.

SUMMARY OF THE INVENTION

It is an object of some of preferred embodiments of the invention to provide a sensor for detecting vibrations conducted to the sensor through a body, while rejecting airborne sounds such as speech. Preferably, vibrations to be detected are those caused by body sounds.

In accordance with a preferred embodiment of the invention, the sensor performs at least two measurements, where the relative polarity of the body sounds and the airborne sounds is different in the two measurements.

In accordance with a preferred embodiment of the invention, the measurements are performed by transducers. Preferably, the transducers are piezoelectric elements.

In accordance with a preferred embodiment of the invention, the piezoelectric elements are mechanically connected to membranes which vibrate in response to body and airborne sounds. Preferably, one of the membranes is in contact with the body.

Further, in accordance with a preferred embodiment of the invention, the membranes, preferably metallic, are mechanically coupled to each other, preferably by a gas or liquid.

In some preferred embodiments of the present invention, the output of transducers are combined, preferably by a differential amplifier, so that the airborne sounds are at least partly canceled.

In some preferred embodiments of the present invention, airborne sound reaches one of the membranes directly from surroundings, and reaches the other membrane through the body.

In some preferred embodiments of the present invention, the amplitude response to airborne sounds of the membrane receiving such sounds directly is adjusted so as to be as close as possible to the amplitude response to airborne sounds of the membrane in contact with the body.

In some preferred embodiments of the present invention, the adjustment of the amplitude response is made by mechanically loading the membrane facing the air, preferably by coating the membrane with a thin layer of a substance.

In some other preferred embodiments of the present invention, the amplitude response adjustment is made by an electrical trimmer and/or by utilizing weighted combination of the amplitude response of the two membranes when combining the outputs of the elements.

In some preferred embodiments of the present invention, the amplitude response adjustment is automatically performed to calibrate the sensor.

There is thus provided, in accordance with a preferred embodiment of the invention, a device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

Preferably, the second portion of said primary sensor signal is responsive to airborne sound which travels to said first sensor via said body.

In a preferred embodiment of the inventor the device includes a secondary sensor which receives airborne sound and produces a secondary sensor signal wherein said airborne sound cancellation circuitry utilizes said secondary sensor signal to produce said output signal. Preferably, the secondary sensor signal comprises first and second portions responsive to said sounds generated within the body and said airborne sounds.

In a preferred embodiment of the invention the cancellation circuitry combines a signal derived from the secondary sensor signal with a signal derived from the primary sensor signal in forming said output signal.

In a preferred embodiment of the invention, the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to increase said second ratio. Preferably, equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals. Alternatively, the equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

In a preferred embodiment of the invention, the device includes equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

In a preferred embodiment of the invention, the device a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value. In a preferred embodiment of the invention the thus produced airborne sound is essentially a single frequency sound. Alternatively, the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

In a preferred embodiment of the invention, the primary sensor comprises a primary membrane and a primary transducer and the primary transducer produces said primary sensor output responsive to deformations of the primary membrane. Preferably the primary transducer is a piezoelectric element.

Preferably, the secondary sensor comprises a secondary membrane and a secondary transducer and the secondary transducer produces said secondary sensor output responsive to deformations of the secondary membrane. Preferably, the secondary transducer is a piezoelectric element.

Preferably, the secondary membrane is displaced from the first membrane.

In a preferred embodiment of the invention the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

In a preferred embodiment of the invention the secondary member is coated with a membrane having a response similar to that of the human skin.

In a preferred embodiment of the invention, the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

In a preferred embodiment of the invention, the first and second sensors are mechanically or acoustically coupled such that vibrations of said primary membrane cause vibrations of the secondary membrane. Preferably, the coupling comprises a closed volume of gas or liquid and the primary and secondary membranes each form portions of an enclosure of the volume.

Preferably, the membrane is a metallic membrane.

There is further provided, in accordance with a preferred embodiment of the invention a device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal from a said primary output signal to produce an output signal having a reduced component responsive to the airborne sound.

Preferably, the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component responsive to the airborne sound. Preferably, the equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals. Alternatively the equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

In a preferred embodiment of the invention, the device includes equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound. Preferably the device includes a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value. In a preferred embodiment of the invention, the thus produced airborne sound is essentially a single frequency sound. Alternatively, the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

There is further provided, in accordance with a preferred embodiment of the invention a method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to preferred embodiments of the invention against the body; and

producing an output signal.

There is further provided, in accordance with a preferred embodiment of the invention, a method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds..

In a preferred embodiment of the invention, providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is reversed for the second signal as compared to the first signal.

In a preferred embodiment of the invention, the method includes adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

Preferably, the adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

In a preferred embodiment of the invention, the adjustment is frequency insensitive. Alternatively, the adjustment varies with frequency.

The present invention will be more clearly understood from the following description of the preferred embodiments of the invention taken together with the following drawings in which:

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 schematically shows the logic of operation and a cross-sectional view of the construction of a sensor, in accordance with a preferred embodiment of the present invention and

Fig. 2 schematically shows a cross-sectional view of the construction of a sensor in accordance with an alternative preferred embodiment of the invention and a preferred method of mounting the sensor.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 schematically depicts the logic of a sensor **6** in accordance with a preferred embodiment of the present invention. Sensor **6** comprises a pair of membranes **10** and **12**, a pair of transducers **14** and **16**, a combiner **18** and a housing **42** to which the membranes **10** and **12** are attached. A gas or liquid **22** fills enclosure **20** and mechanically couples membranes **10** and **12**. Use of different gases or liquids **22** will result in different mechanical coupling of membranes **10** and **12**.

When vibrating, membranes **10** and **12** transfer their vibrational energy to transducers **14** and **16** to which they are conductively glued. Transducers **14** and **16** transform this energy into another form, preferably electrical energy. Outputs **30** and **32** of transducers **14** and **16** are combined by combiner **18** and extracted from sensor **6** as a final output **40**.

Membranes and surfaces vibrate whenever sound or vibrations reach them, as for example surfaces **24** of a body **26** under the influence of body sounds **28** created inside body **26**. To detect vibrations induced by body sounds **28**, the surface of membrane **10** is brought into contact with surface **24**. For reasons of clarity the contact of membrane **10** and surface **24** is not shown in Fig. 1, however, they are shown in contact in Fig. **2** which is shows an alternative preferred embodiment of the invention. Vibrations induced by body sounds **28** which reach surface **24** (arrow **III**) are transmitted to membrane **10** by physical contact and then, through coupling medium **22**, to membrane **12** arrow (arrow **IV**). Airborne sounds **34** such as speech, are transmitted directly to membrane **12** (arrow **V**) and through body **26** (arrows **VI**, **VII**) to membrane **10**. The relative polarity of body and airborne vibrations received by membrane **10** (arrows **III** and **VII**) is different from the relative polarity of those vibrations received by membrane **12** (arrows **IV** and **V**). Combiner **18** combines outputs **30** and **32** so as to subtract the portion of the output generated by airborne sound **34** which reaches membranes **10**, **12**, and to add the portion of the output generated by body sounds **28**. In a preferred embodiment of the invention, the amplitude of vibrations induced by airborne sound **34** in membrane **12** is controlled, as to match it as closely as possible to the amplitude of vibrations induced by airborne sound **34** in membrane **10** so that the amplitude response of the two transducers to airborne sounds is substantially the same. Airborne sound which may reach membrane **10** through the coupling medium does not affect the proper operation of a sensor built in accordance with this embodiment, because the amplitude of vibrations induced by airborne sound **34** in membrane **12** is matched as closely as possible to the algebraic sum of the amplitudes of airborne sound received at membrane **10** through the body and through coupling medium. Additionally or alternatively, the efficiency of coupling medium **22**, does not affect the proper operation of a sensor built in accordance with this embodiment, because, even if no body sound **28** can reach membrane **12**, cancellation of airborne sound in accordance with the above, will still be performed by controlling the amplitude of vibrations induced by airborne sound in membrane **12**, with no dependence on relative polarity of sounds detected by membranes **10** and **12**.

In a preferred embodiment of the invention, the amplitude of vibrations induced by airborne sound in membranes **10** and **12** is obtained by contacting membrane **12** with substance **36** which alters its amplitude response, preferably matching its response to that of the human skin. Alternatively or additionally, the response is altered by putting some distributed weights, (not shown), on the membrane. Alternatively or additionally, airborne sound **34** which reaches membranes **10**, **12** in different directions, is electronically canceled by weighted combination of outputs **30** and **32**. In a preferred embodiment of the present invention, algebraic addition of outputs **30** and **32** is performed in combiner **18** after the amplitude of output **32** is multiplied by a factor which matches it as closely as possible to the amplitude of part of output **30** related to airborne sound. Alternatively, the amplitude of output **32** is controlled by a trimmer **46** before it is combined with output **30**. It should be noted that to the extent that the response is matched mechanically, the system becomes relatively immune from electromagnetic interference.

Membranes **10** and **12**, preferably are thin metallic sheets made of stainless steel, preferably between 200 and 250 microns thick. The membranes are preferably conductively glued to transducers **14** and **16** and, at contact points **48**, to a preferably conductive sensor housing **42**. Transducers **14** and **16** are preferably piezoelectric crystals (PZT) although other transducers such as optical transducers may be used. Inner faces **52** and **54**, of PZTs **14** and **16** are respectively conductively connected to output wires **30A** and **32A**, while sensor housing **42** is grounded through wire **32B** at contact point **50**. Thus, the outer faces of transducers **14** and **16** are also grounded. Vibrations of membranes **10** and **12** induced by airborne sounds **34** in the directions of arrows **V** and **VII**, and by body sounds **28** in the direction of arrow **III** and **IV**, cause mechanical deformations on both PZT's which generate voltage difference between sensor housing **42**, and PZT's inner faces **54**, **52**. These voltage differences are of different polarity when related to airborne sounds, and of same polarity when related to body sounds. Electrical signals caused by the deformation of the PZTs are conducted through shielded, **38**, active wires **30A**, **32A** to combiner **18** which is preferably a differential amplifier.

Utilizing the above configuration, the part of outputs **30** and **32** related to airborne sounds **34** are canceled by differential amplifier **18**, while the part related to body sounds **28** is extracted as final output **40**.

In a preferred embodiment of the invention, the output of transducer **16** is additionally fed to a second operational amplifier (not shown), for use by breath sound equipment as an ambient noise detector.

As indicated above, in some of the preferred embodiments, the amplitude of vibrations induced by airborne sounds **34** in membrane **12** is matched to that induced in membrane **10** by contacting it with a substance **36**, preferably by coating or pasting a thin layer on membrane **12**. It has been found that a closed cell foam tape such as 3M type 1772 Foam Medical Tape with a thickness of 1.2 mm is suitable.

Alternatively or additionally, in some preferred embodiments, electronic adjustment of the amplitude of signals **30** and **32** is used. In these embodiments, trimmer **46** is adjusted to match the amplitude of the outputs of transducers **14** and **16** to airborne sounds.

In a preferred embodiment of the invention, the transducer **16** may be calibrated, in situ, to provide optimum cancellation of airborne sounds. In this embodiment, after placement of the sensor on the body, airborne sound is generated. This sound may be speech or other sound. Trimmer **46** or the relative gain of the channels of combiner **18** are varied to provide minimum signal, at **40**, from such sounds.

In a further preferred embodiment of the invention, alternative or additional to trimmer **46**, a servo controlled equalizer is used to equalize, at predetermined frequencies of the audio spectrum, the part of outputs **30** and **32** generated by airborne sounds. In this preferred embodiment of the invention airborne sound preferably at individual frequencies is generated, preferably corresponding to the center frequencies of bands of the equalizer. Circuitry receives the outputs generated in response to sound at the individual frequencies and changes the respective channel transmission of the equalizer until the output at **40** is minimized or eliminated.

Fig. **2** shows a sensor, in accordance with an alternative preferred embodiment of the invention, in which housing **42** is formed of a plastic material. For this embodiment membranes separate connection is preferably made to the outside surfaces of transducers **14** and **16**, preferably via membranes **10** and 12. In this case epoxy **48'** need not be conductive.

Fig. **2** also illustrates a preferred method of attaching the sensors of Figs. **1** or **2**. In this embodiment the sensor is surrounded by a sponge holding fixture **100** (which may be of the same material as forms the layer **36** of Fig. 1). The height of fixture **100** may be the same as or slightly less than that of housing **42**. Preferably fixture **42** is formed with a slit to allow for the easy removal of the sensor output cable shield **38** and the wires it contains. Fixture **100** is further formed with a sticky surface where it touches the skin of the subject such that it is securely, but removably attached thereto. In this preferred embodiment of the invention, a layer **102** of tape is preferably used to secure the fixture to the sensor. In a preferred embodiment of the invention, tape **102** is of the same material as described above with respect to the preferred embodiment of layer **36** of Fig. **1**. Thus, tape **102** provides the double function of securing the sensor and providing the desired loading of membrane **12**.

It is understood that the operation of a sensor in accordance with the logic and preferred embodiment of the present invention, is independent of the relative and absolute positioning of its constituent components. It is also understood that all the specific elements described above are only representative of their functions, any other elements performing the same functions may be used in the construction of a sensor which acts in accordance with a preferred embodiment of the invention.

CLAIMS

1. A device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

2. A device according to claim 1 wherein the second portion of said primary sensor signal is responsive to airborne sound which travels to said first sensor via said body.

3. A device according to claim 1 or claim 2 and including a secondary sensor which receives airborne sound and produces a secondary sensor signal wherein said airborne sound cancellation circuitry utilizes said secondary sensor signal to produce said output signal.

4. A device according to claim 3 wherein said secondary sensor signal comprises third and fourth portions responsive to said sounds generated within the body and said airborne sounds.

5. A device according to claims 3 or claim 4 wherein the cancellation circuitry combines a signal derived from the secondary sensor signal with a signal derived from the primary sensor signal in forming said output signal.

6. A device according to any of claims 3-5 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to increase said second ratio.

7. A device according to claim 6 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

8. A device according to claim 6 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

9. A device according to any of claims 6-8 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

10. A device according to claim 9 an including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

11. A device according to claim 10 wherein the thus produced airborne sound is essentially a single frequency sound.

12. A device according to claim 10 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

13. A device according to any of claims 3-12 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

14. A device according to claim 13 wherein the primary transducer is a piezoelectric element.

15. A device according to claim 13 or claim 14 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor signal responsive to deformations of the secondary membrane.

16. A device according to claim 15 wherein the secondary transducer is a piezoelectric element.

17. A device according to claim 15 or claim 16 wherein the secondary membrane is displaced from the first membrane.

18. A device according to any of claims 15-17 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

19. A device according to any of claims 15-18 wherein the secondary membrane is coated with a film to have a response similar to that of the human skin.

20. A device according to any of claims 15-18 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

21. A device according to any of claims 15-20 wherein the first and second sensors are mechanically or acoustically coupled such that vibrations of said primary membrane cause vibrations of the secondary membrane.

22. A device according to claim 21 wherein the coupling comprises a closed volume of gas and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

23. A device according to claim 21 wherein the coupling comprises a closed volume of liquid and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

24. A device according to any of claims 13-23 wherein the membrane is a metallic membrane.

25. A device according to claim 1 or claim 2 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

26. A device according to claim 25 wherein the primary transducer is a piezoelectric element.

27. A device according to any of claims 1, 2, 25 or 26 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor output responsive to deformations of the secondary membrane.

28. A device according to claim 27 wherein the secondary transducer is a piezoelectric element.

29. A device according to claim 27 or claim 28 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

30. A device according to claim 27 or claim 28 wherein the secondary member is coated with a membrane having a response similar to that of the human skin.

31. A device according to any of claims 27-30 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

32. A device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprising a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal from a said primary output signal to produce an output signal having a reduced component responsive to the airborne sound.

33. A device according to claim 32 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component responsive to the airborne sound.

34. A device according to claim 33 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

35. A device according to claim 34 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

36. A device according to any of claims 33-35 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

37. A device according to claim 36 and including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

38. A device according to claim 37 wherein the thus produced airborne sound is essentially a single frequency sound.

39. A device according to claim 38 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

40. A method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to any of the preceding claims against the body; and

producing an output signal.

41. A method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds.

42. A method according to claim 41 wherein providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is different for the second signal as compared to the first signal.

43. A method according to claim 41 or claim 42 and including adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

44. A method according to claim 43 wherein said adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

45. A method according to claim 44 wherein the adjustment is frequency insensitive.

46. A method according to claim 45 wherein the adjustment varies with frequency.

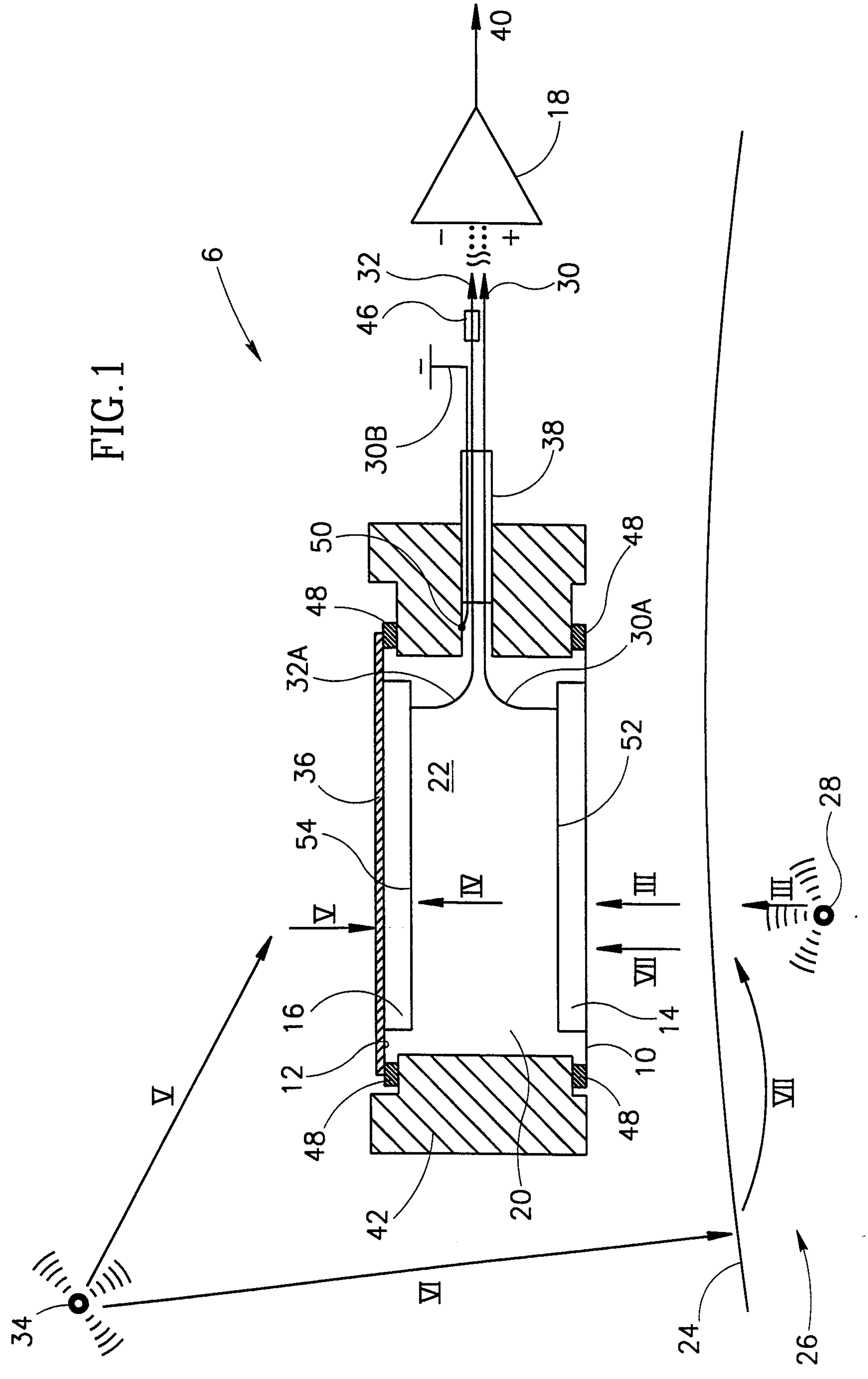
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FIG.1

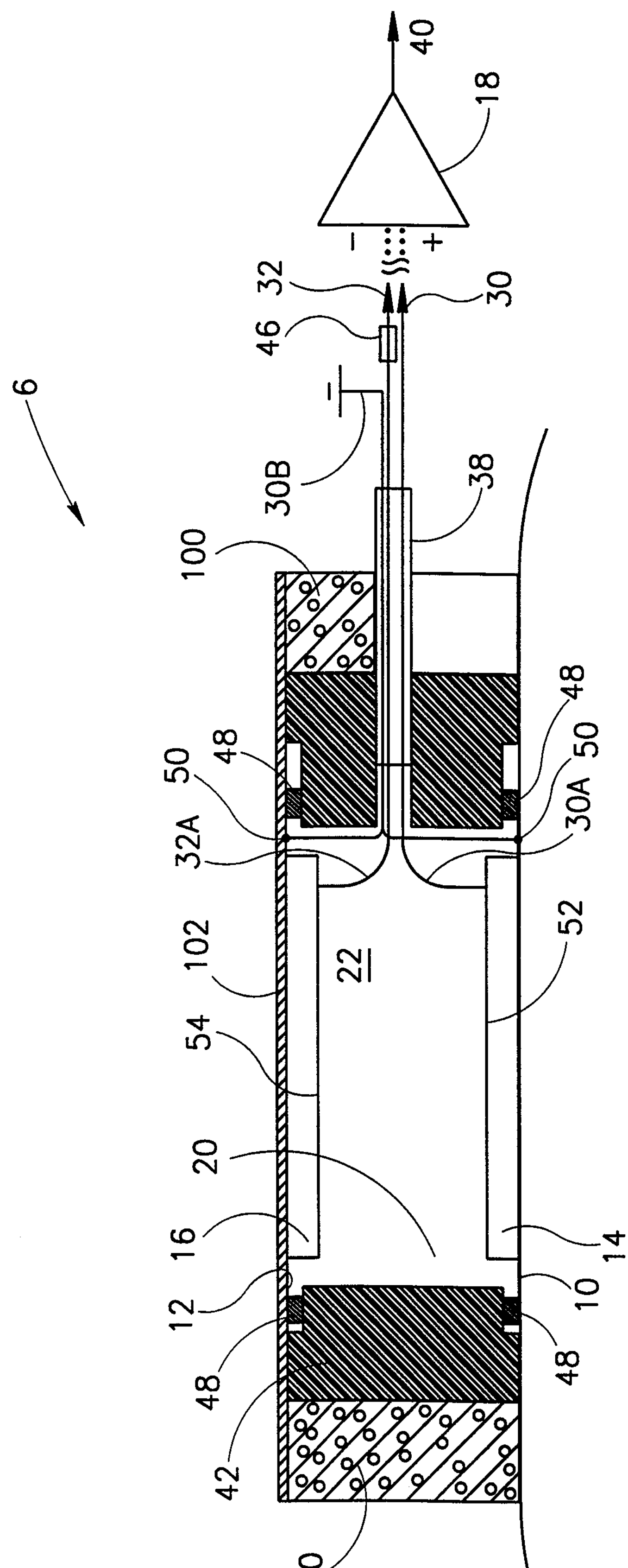
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FIG.2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 98/00172

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01H11/08 G01H1/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01H A61B G01V B06B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 539 831 A (HARLEY THOMAS R) 23 July 1996 see abstract; claim 6; figures 1-3 see column 5, line 22 - line 24 see column 8, line 18 - line 20 see the whole document ---	1-46
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A	see figures 5-7 see the whole document ---	22,23
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[X] Further documents are listed in the continuation of box C.

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15 January 1999	22/01/1999

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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