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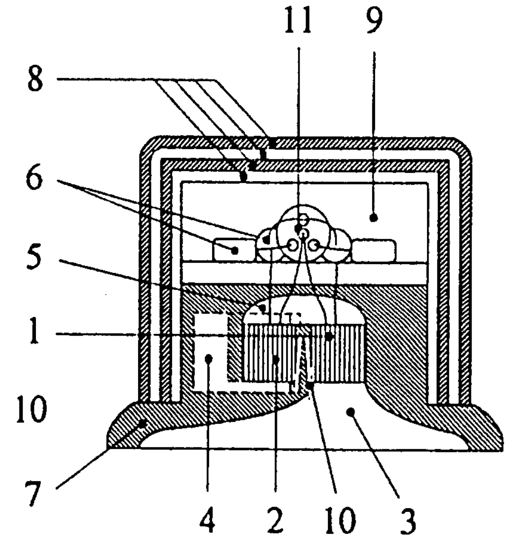
(54) Title: METHOD FOR SUPPRESSION OF INTERFERENCES AND DETECTOR CONSTRUCTION FOR MEASURING SIGNALS FROM THE SURFACE OF SOLID SUBSTANCE

(57) Abstract

The invention relates to an interference suppressing method and a detector construction for measuring a signal from the surface ofa solid substance. In the system of the invention, passive and active interference suppressions are effectively combined. The detector construction includes a first microphone (1) for measuring both the useful signal and the interference signal and a similar other microphone (2) for measuring only the interference signal. The first and second microphones (1, 2) are placed inside a shield shell (7, 8) which passively suppresses the interference signal, at a mutual distance corresponding at maximum to 0.1 times the wavelength of the maximum frequency to be compensated, the passively-suppressed interference signal being coupled to each microphone (1, 2) in almost identical form. In front of both microphones there are chambers (3, 4), separate from each other, their volumes being the same, and the backs of the microphones being in acoustic contact with each other (5). Thus the identical coupling of the interference signal to the microphones is further promoted. Thin pressure-leveling holes (10) leading to the chambers (3, 4) reduce low-frequency pressure variations caused by the target of the measuring. In a simple embodiment the signal of the second microphone (2) is directly subtracted from the signal of the first microphone (1).



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Method for suppression of interferences and detector construction for measuring signals from the surface of solid substance

The invention relates to a method for suppression of interferences of a signal measured from the surface of a solid substance and to a detector construction applying this method. The invention can be applied to the measuring of a sound signal in, for example, technological and medical research and diagnosis tasks.

Active suppression is previously known from many applications in which the purpose is to suppress audible interference, i.e. noise, by producing a counter sound. Detrimental vibration is suppressed by active vibration suppression methods. Efforts have succeeded best in the suppression of so-called unidimensional low-frequency (below 300 Hz) sound, which typically travels in, for example, ventilation duct systems (US Patent 2,043,416). Compensation of a two- or three-dimensional sound is more difficult and is usually successful only within a narrow frequency range, since the counter sound must be in a phase opposite to that of the original and thus it requires high temporal precision. Systems in which noise is suppressed in the vicinity of a driver's head have been made for, for example, working machines and helicopters. Efforts are made to improve passenger comfort in transportation vehicles through active noise compensation by producing counter sound in the vicinity of the passenger's head. In general the systems are not very practicable. A person has to remain in place, and even the turning of the head will cause the suppression level to vary. At their worst the systems fail and the suppression is either nil or the noise may even increase.

In certain technological and medical recording situations, for example, there is a need to measure a signal from a device or a patient under interference conditions. In such a case a useful signal can be obtained by measuring from the body surface or device surface, but simultaneously there arrives an interference (sound) signal three-dimensionally via the air, and it becomes summated with the signal being measured. The problem is worst when the signal being measured is weak. In such a case it is necessary to use sensitive detectors, such as a microphone which records precisely also changes of ambient air pressure, i.e. the interference signal.

In one application function, the recording of breathing and heart sounds, high-grade microphones and only passive noise shield are used. The noise shields used, e.g. a hearing protector in the back wall of which there is installed a rather large-sized microphone, are too sizeable in construction, especially for measuring performed on a child, but also on the neck of an adult. Microphones even entirely without interference shield are used, in which case the measuring room must be silenced for the duration of the recording. When acceleration detectors are used for the measuring of sound, interferences arriving via the air are coupled to the signal to only a small degree. The use of acceleration detectors has, however, more limitations in, for example, medical sound examinations owing to their insensitivity and their frequency range being limited to lower frequencies.

To solve the problems described above, the object of the present invention is to provide efficient noise suppression for measuring needs in medicine and technology in situations in which, for example, often rather weak signals, e.g. sound signals, are to be measured in environments having interference and noise. Certain prior-art methods which are to some extent close to that of the invention in their application or implementation are discussed below as the state of the art.

Swedish lay-open print SE-452 946 discloses an arrangement intended for detecting breathing; in its embodiment example, the sound of breathing is measured with one microphone from the front of the human throat, and another microphone is placed to the side of the throat, on the neck, or behind the ear. One signal is subtracted from the other, and as the result an indication that the patient is breathing is obtained. The solution seems simple, but for a person expert in sound processing technology it is clear that, the microphones being at some distance from each other and no attention having been paid to their shielding, the functioning of the system requires a preliminary processing of the signals, which in the system of the publication includes filtering of low sounds, rectification of the sound signals, and averaging of the signals over a certain period. The result obtained is, in accordance with the object of that invention, a voltage which indicates only breathing, and the actual sound signal is no longer present. The system is not suitable for purposes in which it is desired to purify the original signal from the interference sounds of the environment and to maintain the signal as intact as possible in its original waveform.

Application publication WO-90/09083 describes a microphone for measuring body sounds. The system is based on a solid and closed chamber inside which there is a mass element suspended from a flexible membrane. The membrane divides the chamber into two sections, from which the sound is directed via two air tubes to two microphones, the signals arriving at the microphones being summated by using an electronic bridge circuit. The signal is obtained from the counter vibration of the chamber and the mass inside it, and via opposite pressure variations generated on account of this in the two chambers. There is the problem that the summation of signals from two opposite-phase pressure chambers via two microphones leads not only to noise compensation but also to the compensation of the low-frequency signal. Also, the system is insensitive, since body noise vibrations must move the entire shell structure. Furthermore, soft tissue and the detector mass constitute a harmonic vibrator having a resonance frequency. With the exception of the solid, single-layer shell, no passive noise shield is used and, for example, the microphone elements are free and thus exposed to interference. In spite of this, it is not required in the patent publication that the microphone elements should be located close to each other. The publication does not present examples indicating within what frequency range and at what level the suppression of noise is successful.

Patent US-4,985,925 discloses an active noise suppression system which is designed primarily as an electronically operated hearing protector to be installed in the auditory canal of the ear and for facilitating communication in noisy conditions. The system is made up of an adapter to be installed in the auditory canal and of an electronic hearing protector installed inside the adapter. The frame structure constitutes a passively suppressing shell part inside which there is a bilateral transducer, which serves as a microphone and an amplifier. In its capacity as a microphone the transducer-amplifier measures passively-suppressed ambient sound. To this is summated acoustically a differential sound, which is obtained when the electronic signal generated by the microphone is subtracted from the useful signal. Differentiation between useful signals and interference signals is partly based on the fact that a useful signal is directed to the hearing protector via a separate wire from the outside, and partly on a frequency division: the useful signal, for example speech, is weighted to higher frequencies than are the ambient interferences, for example industrial and traffic noise. The useful signal is pre-filtered and amplified. The suppression, which is weighted to low frequencies, is based on immediate recognition of the mechanical movement of sound pressure and on its compensation by means of an electromagnetic counter force obtained by negative feedback. The achieved upper frequency limit of active compensation is approx. 1 kHz. The disclosed compensation works relatively well in the auditory canal, which is a nearly unidimensional space.

It is further stated in publication US-4,985,925 that its system can also be applied to a stethoscope. The detector end of the stethoscope is in this case conventional, and the hearing protector according to the system is located in the auditory canal in order to suppress ambient noise during the auscultation of a patient. The compensation is based on one microphone, into which useful signals and interference signals are summated acoustically. The useful signal may be taken from an external source, for example a microphone, into which the signal must be measured with less interference than is present at the location of the ear. In the case of a stethoscope, the patient and the detector end of the stethoscope are, however, in the same room space as the auscultating person and his or her ears, in which case the hearing protectors are not of great use, since the noise is coupled to the signal via the detector end.

In the present invention, the principle of the system is that no counter sound is produced; the object is to obtain as pure a signal as possible in interference conditions by acoustically measuring any interferences in identical form with two microphones and by compensating them thereafter electronically at the line level. This can be done successfully only if the detector construction is acoustically correctly constructed and calibrated.

The system according to the invention is characterized by the measuring of a useful signal from the surface of a solid substance by using one microphone and the simultaneous measuring, with two microphones, of the medium (air, other gas, liquid) surrounding the measuring point. The interferences can be eliminated from the useful signal by summating it with an inverted interference signal. The detector construction includes an efficient passive hearing protector. Inside the protector there are needed two microphones, enabling active interference suppression to be implemented. The distance between the microphones is minimal, owing to which a good compensation level and rather high compensation frequencies are achieved.

The microphones are planted tightly in an acoustically good insulation material, in which an acoustic chamber is made in front of each microphone, the chambers being insulated from each other, in which case, in spite of the short distance, the useful signal will not pass into the microphone measuring only interferences. The acoustic chambers are of equal volume, the object being to equalize (same spectrum) the interference signal coupling to the microphones. The back sides of the microphones are in direct acoustic contact with each other, and thus the mutual distance between the microphones is minimal with respect to an interference signal.

The obtaining of the useful signal is promoted by a wide and low and small-volume acoustic chamber, and thus the resonance frequency of the chamber is sufficiently high so that it will not distort the signal being measured.

From the chambers there lead out thin symmetrical pressure-leveling holes which reduce very low-frequency interferences due to the target of the measuring and improve the compensation result.

The microphones serve simultaneously both as detectors and as physically insulating plugs.

The signals of both microphones can be recorded from their own wires, in which case the compensation can be carried out either electronically by circuit techniques or, for example, by computer, in which the compensation can be further promoted by combining mathematic and signal-processing methods with the processing.

The interference suppression method according to the invention for improving the quality of a signal measured from the surface of a solid substance is characterized in what is stated in Claim 1.

The detector construction according to the invention is characterized in what is stated in Claim 4.

The other claims present embodiments of the interference suppression method and detector construction according to the invention.

By the method and the apparatus according to the invention, crucial improvements are achieved over the state-of-the-art technology described in connection with the discussion of the state of the art. First of all, by using the invention, a clearly better compensation result than in the compensation systems described is achieved without substantially altering the original signal. Thus it is possible to use the signal from which interferences have been eliminated for precise waveform and frequency analyses after the compensation. Second, a better overall interference suppression is obtained by using the invention than by known detector systems. Third, the efficiency of the signal capture of the detector construction under interference conditions is better, especially at high frequencies, since the main microphone is in direct contact with the surface to be measured. Furthermore, the detector construction according to the invention can be made significantly smaller in size than the existing systems, since the only limitation is the size of the microphone elements available.

The detector construction can be simple, since no electronic compensation circuits are included. The compensation of the two signals obtained is carried out subsequently, either in real time or later on recorded signals. The essential idea is that the signals are obtained from microphones for further processing. The upper limit of compensation is dependent only on the size and mutual distance of the microphone elements and is higher than, for example, in the system of patent US-4,985,925, in which the useful and interference signals are separated from each other in the compensation circuit by filtration, which means a significant modification of the useful signal. In the present invention, the signal is obtained in its original form directly from the surface of a solid substance. The signal source is protected from noise passively when the detector construction is placed physically over the measurement point and is pressed tightly against the surface.

The invention is described below in detail, with reference to the drawings, in which:

Figure 1 depicts one embodiment of the detector construction according to the invention as seen (a) from below, (b) from the side, (c) from above, and (d) from behind, and

Figures 2 and 3 depict the results of frequency response measurements made for testing the detector construction of Figure 1.

Figure 1 shows an interference-compensating detector construction which measures from the surface of a solid substance and has been constructed for medical measuring, especially the measuring of breathing sounds, but is also suitable for measuring the sounds of other organs, such as the heart, and for many technical measurements in industry.

The capsule size of the microphones 1, 2 used is small, and their mutual distance is short, and therefore the achieved compensation band is wide, ranging from below 50 Hz to over 5000 Hz (Figures 2 and 3). At the same time the construction can be made small, light, and easy to use; for this reason also the battery needed to provide the operating voltage for the microphones is placed at the other end of the wire 11. The detector construction implemented includes an efficient passively suppressing multiple-layer shell part 8, which is made up of hard and porous layers constructed one inside the other; in the example device there are two pairs of layers. Suppression is more efficient the greater the number of layers in the construction. The shell part is connected to and the microphones are planted tightly in an acoustically good insulation material 7, in which there is in front of each microphone element a chamber 3, 4, the chambers being separate from each other; thus, in spite of the small distance, the useful signal will not pass to the interference microphone. The back sides of the microphones are in direct acoustic contact with each other via a chamber 5, the function of which is to implement the coupling of the interference signal arriving through the passive shield 7, 8 in identical form to each microphone. The useful signal is obtained through a wide and low, which properties amplify the signal, and sufficiently small acoustic chamber 3, and therefore the resonance frequency of the chamber is so high that it will not distort the signal. In front of the microphone 2 which measures interferences there is an acoustic chamber 4, the function of which is to acoustically equalize the interference signal coupling to the microphones. The chamber 4 is of approximately the same size as the chamber 3 in the situation of use, since the chamber 3 decreases when the construction is pressed against a patient's skin, the skin bulging slightly into the chamber. From the chambers there lead out thin pressure-leveling holes 10, which are located very close to each other on the outer surface. The holes reduce the very low-frequency pressure variations caused by the target of the measuring and improve the compensation result. The interior space containing the components 6 of the pre-amplifiers of the microphones is effectively acousticized with a suppression material 9 to prevent echoes and resonances.

In the present invention, active suppression is based on two identical, mutually very closely positioned small-size microphones, in the implemented construction two microphones 1 and 2, the signals of which can be combined so that the interferences in the useful signal are suppressed by the signal obtained via the microphone 2 which measures only interferences. The function of the multiple-layer, efficient passive noise shield 8 which serves as the shielding shell of the detector construction is to suppress all, but primarily high, frequencies. Passive suppression has an identical effect on the interference signal arriving at each microphone, i.e. even before being subjected to active suppression the disturbances are already passively suppressed. The function of the active suppression is to reduce primarily low interference frequencies, which a passive shield in a small-size construction will not, for physical reasons, affect very effectively. In order that as good a signal as possible should be obtained with the detector construction, the useful-signal microphone must have a good contact with the surface being measured. This contact takes place directly and efficiently via an acoustic chamber 3, when the detector construction is pressed against the surface being measured. In order for the compensation to be maximally effective, the interference signal must be coupled in as identical a form as possible to the two microphones. This is implemented more efficiently the closer the microphones are to each other. Since the microphones cannot be at exactly the same point, the situation is improved if the acoustic conditions of the microphones, such as the chambers 3 and 4 in front of them, acoustically correspond to each other to a high degree, and the chamber 5 behind them is similar for each microphone. The pressure-leveling holes 10 leading out of the chambers also must be of the same size and length. In order that any external pressure fluctuations entering through the holes arrive simultaneously at both microphones, the outlets of the holes must be quite closely located on the outer surface. However, the holes must not join, because then the useful signal would pass, weakened, also to the interference microphone via the ducts 10 and lead to partial compensation of the useful signal.

In order that the microphone elements could be placed very close to each other, they must be embedded tightly in a rigid acoustic insulation material, in this construction in the frame 7. The microphone capsules serve, in addition to their principal function, as acoustic plugs, since the useful signal arriving via the chamber 3 must not pass behind the microphones, where the connecting chamber 5 connects the microphones closely to each other acoustically. The function of the connecting chamber is to cause the interference signal to couple to each microphone in an identical form in order than the compensation result should be as close to zero as possible, so that only the useful signal remain, pure. The chamber 4 of the microphone 2 which measures only interferences does not communicate with the acoustic chamber 3 of the useful signal; in between there is a sturdy, effectively insulating wall of the frame material 7. In the interior space of the construction there are located the electronic components 6 required for the pre-amplifiers of the microphones. Any space remaining free is filled with an acoustically suppressing material 9, in order that the level of the interference sounds be maximally low, echo-free and unresonating. The pressure leveling holes 10 let in some pressure variation, i.e. the noise level coupled to the microphone capsules rises, but at the same time the compensation improves. The effect is strongly dependent on the diameter and length of the holes, and the ratio of these dimensions.

Figures 2 and 3 depict results of frequency response measurements made for testing the implemented example detector construction. Figure 2 shows the intensity curves in white noise and a suppression comparison, when the detector construction is tuned to active suppression, and Figure 3 shows the intensity curves in white noise and a suppression comparison when the detector construction is tuned to passive suppression. It is characteristic of the embodiment example that, during measuring, the detector construction fulfills the curves depicting active and passive suppression, shown in Figures 2 and 3.

White noise was produced using a high-quality hifi loudspeaker from a test CD published by the HIFI magazine, and the measurements were made on a frequency band 40-6000 Hz in an ordinary room. The distance between the loudspeaker and the microphone was 25 cm. The intensity curves in Figure 2 were measured when the detector construction was tuned to active suppression. The curve 'Noise directly' was measured using an open microphone. The 'Useful channel' and the 'Noise channel' were measured in the normal situation of use of the apparatus during background noise, but without the useful signal. By means of the curve, a suppression comparison can be made within the frequency range 50-5000 Hz. It is observed from the curves that passive suppression is effective only from the frequency 2000 Hz upwards, whereas active suppression starts at less than 50 Hz and continues up to 5000 Hz. Compared with the useful channel, the 'Compensated' curve, i.e. active suppression, is significant, i.e. more than 10 dB, within a wide band, 60-3000 Hz, whereas in sound production systems it is possible to achieve even higher dB values, but within a considerably more narrow band. A suitable method of comparing the overall result is to calculate the decibel values for each third-octave band and to summate these. The total suppression result achieved using the invention, calculated from Figure 2, is 231 third-octave decibels, whereas in compensations made with sounds the values achieved are Chelsea method 87 third-octave decibels and counter noise produced in an airplane pilot's earphones 161 third-octave decibels. In US Patent 4,985,925, the value 207.70 third-octave decibels has been achieved within the presented frequency band 100-5000 Hz, whereas the value measured in the corresponding band in the present invention is 210.35 third-octave decibels.

In order to facilitate comparison, Figure 3 shows three of the same curves as are shown in Figure 2 ('Useful channel' = 'Active tuning'), but instead of the noise channel of Figure 2,

Figure 3 has 'Passive tuning', which has been measured while the detector construction had been tuned to passive suppression, which was done by closing the pressure leveling holes (10). Thus the active suppression changes from the level of the 'Active tuning' curve of Figure 3 to the level of the 'Passive tuning' curve. A comparison between the curves 'Passive tuning' and 'Compensated' in Figure 3 shows that active compensation suppresses an amount of 0-12 dB within the frequency band 100-2000 Hz. The total effect of the suppression is 120 third-octave decibels. This suppression can be regarded as an absolute improvement which occurred as a result of the active suppression according to the invention, as compared with the level achieved by passive suppression. It is probable that by tuning and developing the invention even a somewhat better suppression result can be achieved.

Claims

1. An interference suppression method for improving the quality of the useful signal measured from the surface of a solid substance when an interference signal arrives via the ambient medium and when a first microphone (1) is used for measuring the useful signal and the interference signal and a similar or corresponding second microphone (2) is used for measuring only the interference signal, **characterized** in that the effects of passive and active interference suppression are combined

by placing the first microphone (1) and the second microphone (2), acoustically insulated from each other, inside an acoustically suppressing shield shell (7, 8) equipped with a suppression material (9) which prevents resonances and echoes, in order to suppress passively, substantially equally strongly, the interference signal arriving at both microphones (1, 2),

by placing the microphones (1, 2) at a mutual distance corresponding to at maximum 0.1 times the wavelength of the maximum frequency to be compensated, in order that the interference signal be caused to couple to the microphones (1, 2) in a substantially identical form,

by additionally equalizing the coupling of the interference signal to the microphones (1, 2) by means of a chamber arrangement including at least a first chamber (3), which primarily directs the useful signal to the first microphone (1), in front of the first microphone (1), and a second chamber (4) in front of the second microphone (2), the chambers corresponding to each other, and by means of a chamber pressure leveling arrangement (10), and

by eliminating a signal according to the signal obtained from the second microphone (2) from the signal obtained from the first microphone.

2. An interference suppression method according to Claim 1, **characterized** in that a signal according to the signal obtained from the second microphone (2) is eliminated from the signal

obtained from the first microphone (1), by subtracting directly the signal obtained from the second microphone (2) from the signal obtained from the first microphone (1).

3. An interference suppression method according to Claim 1, **characterized** in that the signals of the first and the second microphone (1, 2) are directed separately for further processing, in which case the elimination of a signal according to the signal obtained from the second microphone (2) from the signal obtained from the first microphone (1) takes place after the processing and/or analysis of the signals.

4. A detector construction for measuring a useful signal from the surface of a solid substance when an interference signal arrives via the ambient medium, the construction including a first microphone (1) for measuring both the useful signal and the interference signal and a similar or corresponding second microphone (2) for measuring only the interference signal, **characterized** in that it includes:

an acoustically suppressing shield shell (7, 8), which is equipped with a suppression material (9) preventing resonances and echoes, inside which shield the first microphone (1) and the second microphone (2) are planted at a mutual distance corresponding to at maximum 0.1 times the wavelength of the maximum frequency to be compensated and are insulated from each other, in order to suppress passively and substantially equally strongly the interference signal arriving at both microphones (1, 2), and to enable the passively suppressed interference signal to be coupled to both microphones (1, 2) in a substantially precisely identical form, and

to equalize the coupling of the interference signal to the microphones (1, 2) additionally an arrangement including at least:

in front of the first microphone (1), a first chamber (3), delimited by the surface of the solid substance when the detector is against the surface, the primary function of the chamber being to direct the useful signal to the first microphone (1),

in front of the second microphone (2), a second chamber (4), corresponding to the first chamber (3), formed inside the shield shell (7, 8), and

a pressure leveling arrangement (10) for the chambers.

5. A detector construction according to Claim 4, **characterized** in that the second chamber (4) is designed to have a volume substantially equal to that of the first chamber (3).

6. A detector construction according to Claim 4 or 5, **characterized** in that the said arrangement for equalizing the coupling of the interference signal to the microphones (1, 2) additionally includes in the shield shell material (7) a symmetrical cavity (5) which interconnects acoustically the microphones (1, 2) with the corresponding chambers (3, 4) from their opposite sides.

7. A detector construction according to any of Claims 4-6, **characterized** in that the pressure leveling arrangement of the chambers (3, 4) is made up of corresponding thin pressure-leveling holes (10) leading to the chambers (3, 4) in the shield shell (7, 8) from its outer surface, the holes being equally long and at an equal distance from the microphones (1, 2) and being located immediately side by side on the outer surface of the shield shell (7, 8).

8. A detector construction according to any of Claims 4-7, **characterized** in that the first acoustic chamber (3) is designed so that the ratio of the measuring surface to the chamber volume is great, whereby an amplification effect on the useful signal is obtained.

9. A detector construction according to any of Claims 4-8, **characterized** in that the first microphone (1) at the same time

serves as a plug, i.e. as part of the passive shield of the microphones (1, 2), preventing the access of the useful signal to the second microphone (2).

10. A detector construction according to any of Claims 4-9, **characterized** in that the shield shell (7, 8) is made up of a multiple-layer shell (8) and an acoustically well suppressing frame material (7).

11. A detector construction according to Claim 10, **characterized** in that the frame material (7) is an acoustically well suppressing rubber material.

12. A detector construction according to Claim 10 or 11, **characterized** in that the multiple-layer shell (8) is made up of hard plastic layers and of porous cellular rubber between them.

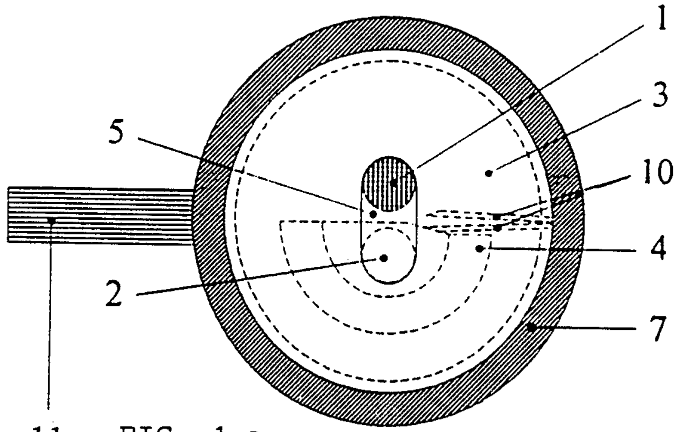


FIG. 1 a

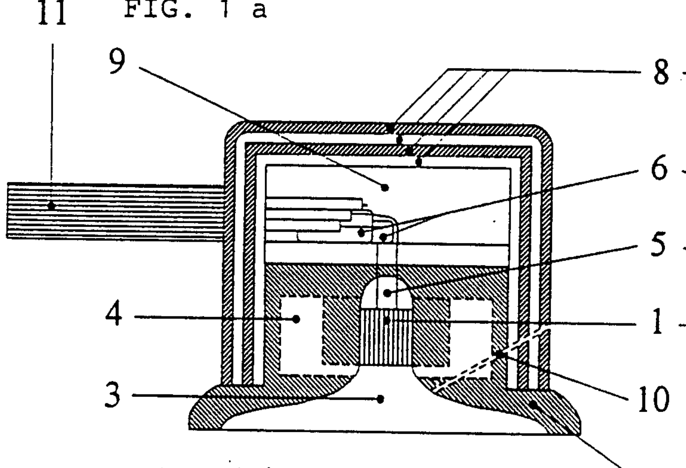


FIG. 1 b

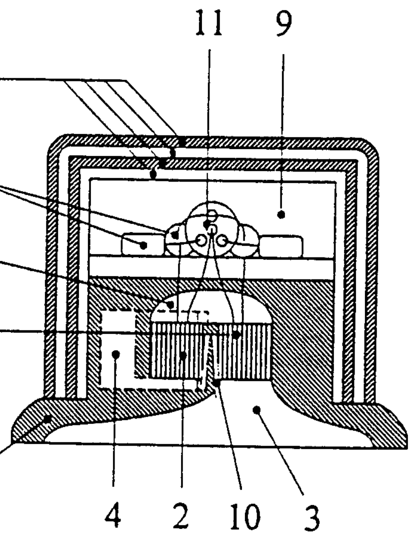


FIG. 1 d

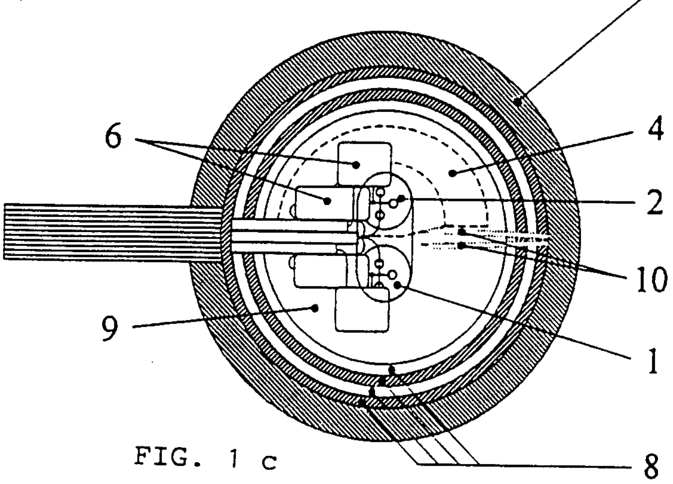
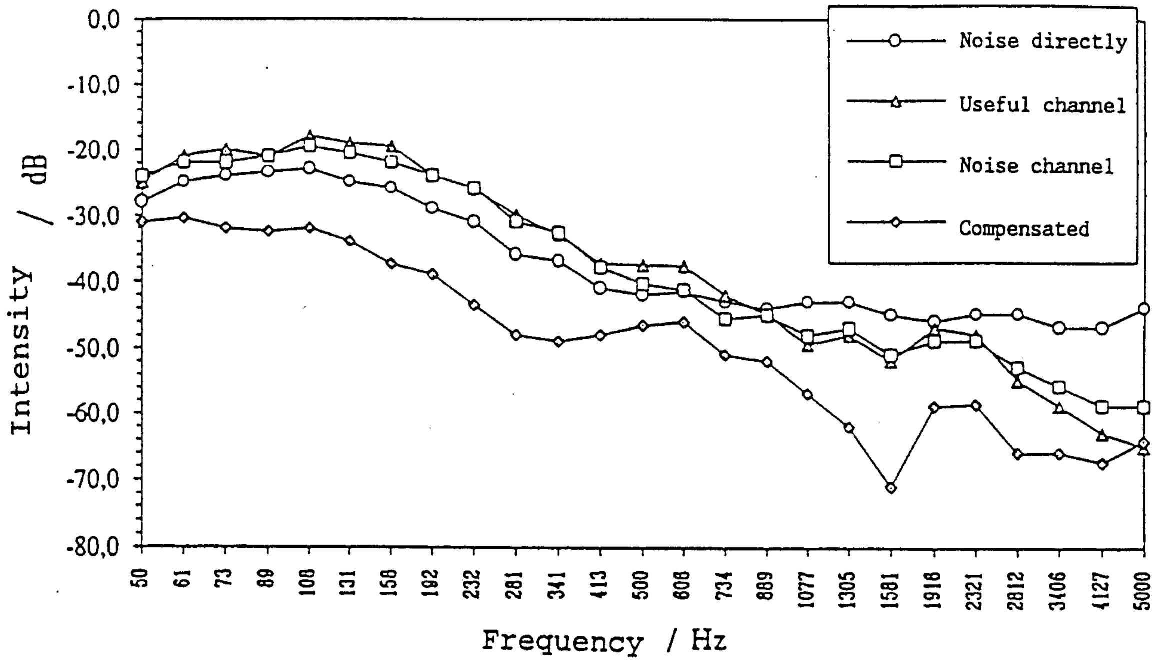


FIG. 1 c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Frequency / Hz

FIG. 2

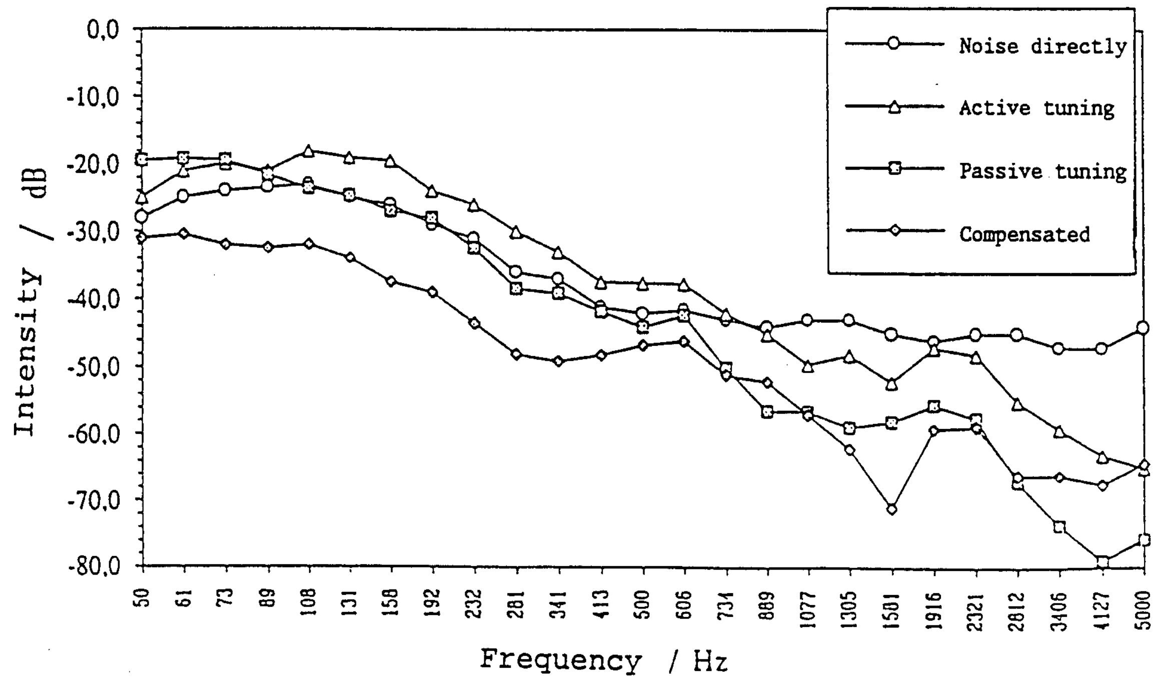
0,0
-10,0
-20,0
-30,0
-40,0
-50,0
-60,0
-70,0
-80,0
Intensity / dB
Noise directly
Active tuning
Passive tuning
Compensated
50
61
73
89
108
131
158
192
232
281
341
413
500
606
734
889
1077
1305
1581
1916
2321
2812
3406
4127
5000
Frequency / Hz

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 94/00165

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: G01H 1/00
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)

IPC5: G01H, A61B, H04R

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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.
A	WO, A, 8700415 (KAROLINSKA INSTITUTET), 22 January 1987 (22.01.87) --	1
A	WO, A, 9009083 (HÖK INSTRUMENT AB), 9 August 1990 (09.08.90), cited in the application --	4
A	EP, A, 0105600 (BECTON, DICKINSON AND COMPANY), 18 April 1984 (18.04.84) --	1
A	US, A, 3133990 (EDWARD S. SEELEY), 19 May 1964 (19.05.64) -- --------	1

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 July 1994	04-08-1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Ingemar Josefsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/07/94

International application No.
PCT/FI 94/00165

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO-A-	8700415	22/01/87	EP-A-	0230407	05/08/87
WO-A-	9009083	09/08/90	AU-A-	5038790	24/08/90
			SE-B,C-	463065	01/10/90
			SE-A-	8900392	07/08/90
EP-A-	0105600	18/04/84	JP-A-	59079817	09/05/84
			US-A-	4506551	26/03/85
US-A-	3133990	19/05/64	NONE		