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(54) **AN OUTDOOR MULTI-MICROPHONE SYSTEM WITH AN INTEGRATED REMOTE ACOUSTIC CALIBRATION**

(57) An outdoor microphone comprising: a microphone assembly (110) mounted in a first housing element (101) and comprising: at least one MEMS microphone configured as a measurement microphone (114); at least one MEMS microphone configured as a reference microphone (115); an amplifier (124) for generating a loudspeaker driving signal; a microprocessor (126) configured to compare the signal level measured by the measurement microphone (114) and the reference microphone (115) and converted by a dual-channel A/D converter (123); a loudspeaker assembly (120) mounted in a second housing element (102) connected with the first housing element (101) and comprising a loudspeaker (135) for generating sound; a springy connector (131) installed inside the outdoor microphone housing elements (101, 102) for connecting the loudspeaker assembly (120) with the microphone assembly (110) to conduct the loudspeaker driving signal; wherein the first housing element (101) has openings (1011) surrounding an open sound cavity for passing ambient sound from the environment and the sound from the loudspeaker assembly (120) located at one end of the cavity to the microphone assembly (110) located at the other end of the cavity.

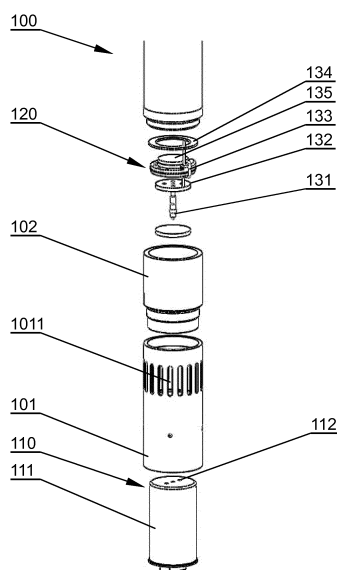


Fig. 1A

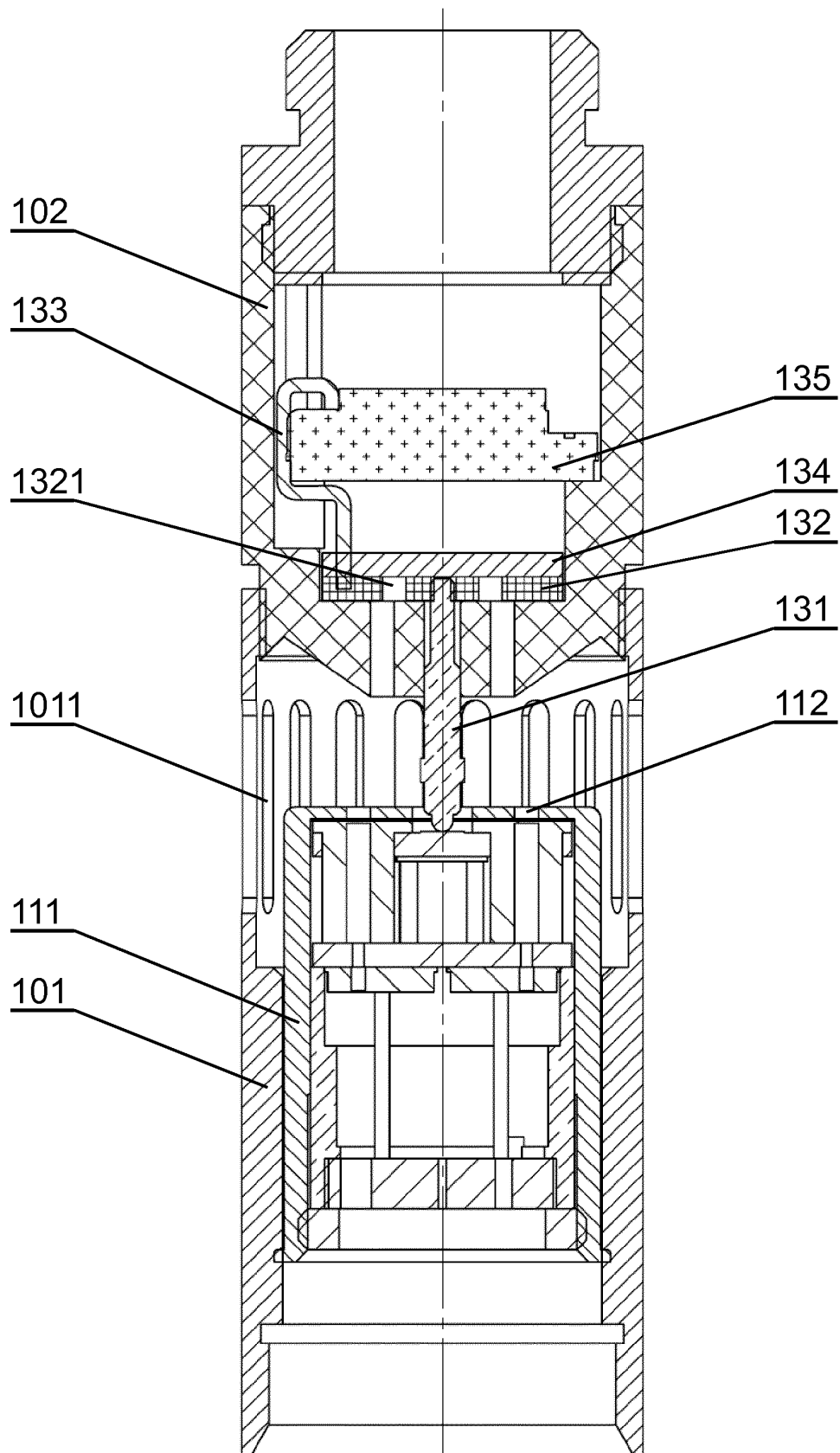


Fig. 1B

Description

TECHNICAL FIELD

[0001] The present invention relates to remote calibration of outdoor microphones.

BACKGROUND

[0002] Outdoor noise monitoring systems are used for long-term measurements of noise, e.g. at roads, airports etc. It is essential to perform periodic calibration of these systems in order to guarantee their correct operation. It is preferred if the calibration can be performed remotely, without a need for an operator to perform manual procedures at the microphone. One of the calibration procedures is to check whether the station is operable.

[0003] So far, outdoor noise monitoring stations used condenser microphones. A condenser microphone can be calibrated by means of an electrostatic actuator that comprises an electrode that permits the application of an electrostatic force to the metallic or metalized diaphragm of the microphone in order to perform the calibration. Alternatively, the equivalent capacitance of the microphone can be measured. It is relatively hard to perform acoustic calibration by performing comparison of sound levels received by the measured microphone and a reference microphone, as the condenser microphones are relatively large and the reference microphone would occupy too much space in the measurement system housing, which must meet strict acoustic requirements.

[0004] A US patent application US20140369511 discloses a self calibrating dipole microphone formed from two omni-directional acoustic sensors. The microphone includes a sound source acoustically coupled to the acoustic sensors and a processor. The sound source is excited with a test signal, exposing the acoustic sensors to acoustic calibration signals, which are of the same phase. The responses of the acoustic sensors to the calibration signals are compared by the processor and a correction transfer function is determined. The system is designed in particular for a dipole microphone.

[0005] MEMS microphones have been recently developed and find more and more applications of use. So far, little research has been conducted on the possibilities of use of the MEMS microphones for outdoor monitoring systems.

[0006] MEMS microphones have very small dimensions, which allows designing a multi-microphone system having a standard dimensions used in acoustic fields (for example, a 1/2" or 1" diameter).

[0007] Providing a proper symmetrical design of the outdoor microphone is very important to meet acoustical characteristics requirements defined in the IEC 61672:2013 for Class 1 or Class 2, typically required for such measurement systems.

[0008] Additionally, such multi-microphone solution offers improved system signal to noise ratio expanding the

lower measuring range of the outdoor microphone.

[0009] The MEMS microphones have no equivalent capacitance that could be measured, as in the case of condenser microphones and they cannot be excited by an electrostatic actuator.

[0010] There is therefore a need to provide an alternative design for an outdoor microphone with an integrated calibration system that will solve the problems mentioned above and allow remote calibration of the microphone.

SUMMARY

[0011] The object of the invention is an outdoor microphone comprising:

- a microphone assembly mounted in a first housing element and comprising: at least one MEMS microphone configured as a measurement microphone; at least one MEMS microphone configured as a reference microphone; an amplifier for generating a loudspeaker driving signal; a microprocessor configured to compare the signal level measured by the measurement microphone and the reference microphone and converted by a dual-channel A/D converter;
- a loudspeaker assembly mounted in a second housing element connected with the first housing element and comprising a loudspeaker for generating sound;
- a springy connector installed inside the outdoor microphone housing elements for connecting the loudspeaker assembly with the microphone assembly to conduct the loudspeaker driving signal;
- wherein the first housing element has openings surrounding an open sound cavity for passing ambient sound from the environment and the sound from the loudspeaker assembly located at one end of the cavity to the microphone assembly located at the other end of the cavity.

[0012] The outdoor microphone may comprise a pair or more of measurement microphones and a pair or more of reference microphones.

[0013] The reference microphones may have a different characteristics (e.g. a narrower measuring band) than the measurement microphones.

[0014] The outdoor microphone may further comprise: an amplifier controlled by a microprocessor; wherein the amplifier is configured to generate the loudspeaker driving signal; and wherein the microprocessor is configured to detect a difference between the signal level measured by the measurement microphone and the reference microphone and to generate a positive system check result signal if the difference is below a threshold and a negative system check result signal otherwise.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The outdoor microphone with integrated remote

acoustic calibration system and a method for remote acoustic calibration are shown by means of example embodiments on a drawing, in which:

Figs. 1A and 1B show an outdoor microphone system in an isometric view (with some elements shown as transparent) and a cross-sectional view;
Figs. 2A and 2B show the microphone assembly in an isometric view (outside the housing) and a cross-sectional view (inside the housing).
Fig. 3 shows a functional schematic of the calibration system.

DETAILED DESCRIPTION

[0016] The outdoor microphone system is shown in Figs. 1A and 1B. It comprises a housing 100 formed of a plurality of elements 101, 102, some of which are detachably joined with each other. The housing is cylindrical, and has preferably a 1/2" diameter. The first housing element 101 is configured to accommodate and seal a microphone assembly 110 and to allow ambient sound to reach the microphone assembly via openings 1011. The first housing element may be surrounded by a protective windscreen (not shown in the drawing). The second housing element 102 accommodates a loudspeaker assembly 120.

[0017] The microphone assembly 110 is powered in a conventional manner, for example via a signal wire (not shown in the drawing) connected to a battery, and the ground terminal connected to the housing, which is preferably made of a conducting metal. The loudspeaker assembly 120 is electrically connected with the microphone assembly via a central springy connector 131 (in form of an elastic pin) for conducting signal to the loudspeaker, and the loudspeaker assembly 120 can be connected to the grounded housing element 102.

[0018] The microphone assembly 110 is accommodated in a housing 111 with openings 112 that act as inlets for sound to the microphones and the springy connector 131.

[0019] The microphone assembly, as shown in details in Figs. 2A and 2B in slanted view and in Figs. 2C and 2D in cross-sections along two planes perpendicular to each other, comprises in this example embodiment a pair of measurement microphones 114 and a pair of reference microphones 115. In other embodiments, more than two measuring or reference microphones can be used. The microphones are preferably MEMS microphones. A pair of microphones with summed outputs connected in parallel is more preferred than a single microphone, in particular for MEMS microphones which have relatively high self noise, to improve the signal to noise ratio. They are mounted to printed circuit boards (PCBs) 116, 117 with their membranes directed towards the PCB, wherein openings 1161, 1171 are made to pass sound from the cavity of the first housing element 101. The PCB 116 has openings 1161 as inlets for sound to the microphones

(which are mounted at the side opposite to the side facing the cavity of the first housing element 101) and a terminal 113 for contacting the springy connector 131. The openings 1171 are made in guiding sleeves 1172 between the first PCB 116 and the second PCB 117.

[0020] The measurement microphones 114 may be of the same or different type as the reference microphones 115. In this example, the reference microphones are smaller, as they have a narrower measurement band (which is enough to cover the frequency of the loudspeaker used for calibration - typically 1 kHz). The reference microphone(s) do not need to be located on the same surface as the measurement microphones, as the loudspeaker acoustic signal RMS value is a subject of verification. This also expands the space for the location of the measurement microphones.

[0021] Other elements of the microphone assembly 110, such as electronic circuits 121-126 for data processing and transmission, can be accommodated on a third PCB 118.

[0022] The loudspeaker assembly comprises a printed circuit board 132 that has openings 1321 that act as outlets for sound from the loudspeaker and connects the springy connector 131 with a wire 133 that conducts signal to a loudspeaker 135. The openings 1321 are covered by an insulating pad 134 that provides insulation from water from the cavity within the first housing element 101. The loudspeaker 135 is directed towards the sound outlet openings 1321.

[0023] The acoustic calibration system operates as follows. The loudspeaker is induced, via a signal passed through the central connector 131, to emit sound that passes via the openings 1311, to the cavity within the first housing element 101. Therefore, the acoustic coupling between the loudspeaker assembly 120 and the microphone assembly 110 is open. The calibration sound that reaches the cavity within the first housing element 101 can be then measured by the microphone assembly 110 in a manner equivalent to the measurement of the outdoor noise. Therefore, the microphone assembly is acoustically excited. The loudspeaker 135 emits sound of a known level stabilized by the feedback loop including the reference microphone 115. This level should be as high as possible to increase the excitation signal as much as possible above of the ambient noise. With the described solution, levels up to 110 dB are provided. It is then checked whether the level of the signal received by the measurement microphone(s) is within the expected level range. If so, it suggests that the microphone(s) are operative. In case the measured signal deviation from the expected value is too big, i.e. it exceeds a predefined deviation threshold, it suggests that the microphone(s) is(are) defective. The results of the system check can be then transmitted to a remote station to inform the operator of the outdoor monitoring system whether the particular outdoor monitoring station is operative or malfunctioning. For example, the calibration procedure (system check) can be performed once a day.

[0024] A functional schematic of the calibration system is shown in Fig. 3. First, ambient sound level received by the reference microphone 115 is measured, converted to a digital signal by an A/D converter 123 and input to a microprocessor 126. Next, an amplifier 124, in response to a signal from the processor 126 and a D/A converter 125, sets the level of the signal driving the loudspeaker 135 via the connector 131 to a high level, for example to a maximum level. The sound level emitted by the loudspeaker 135 should be higher than the ambient sound level, e.g. by 20 dB, which is in some situations not possible, for example when the ambient sound level is high at the moment of performing the calibration - in such situations, the calibration procedure can be stopped and repeated after some time. Next, the microprocessor 126 compares the sound level measured by the reference microphone 115 and the measurement microphones 114. The measurement microphone signals can be input to the microprocessor 126 via a 3 to N cycles commutator 122 or another configuration. In case the levels measured by the reference microphone 115 and the measurement microphones 114 differ by more than a particular threshold, e.g. 2dB, a negative system check result is output by the microprocessor 126. In case the level difference is within the threshold, a positive system check result is output.

[0025] The system has a plurality of advantages. The use of MEMS microphones allows to accommodate the system comprising a plurality of microphones (including a reference microphone and measurement microphone) in relatively small housing, for example a cylindrical housing of a 1/2" diameter. The central springy connector pin allows the housing 102 of the loudspeaker assembly to be conveniently mounted with the other element 101 of the housing, with no wires running outside the housing, which improves the acoustic performances and robustness of the system. Integration of the loudspeaker with the microphone assembly in a single housing 100 allows the outdoor microphone to be calibrated remotely, system check). (The MEMS microphones are induced acoustically by the loudspeaker.

[0026] Absolute calibration by external acoustic calibrator is also very simple just by disconnecting upper part of the housing (including loudspeaker and springy contact) and attaching calibrator directed on microphone housing.

Claims

1. An outdoor microphone comprising:

- a microphone assembly (110) mounted in a first housing element (101) and comprising:

- at least one MEMS microphone configured as a measurement microphone (114);
- at least one MEMS microphone configured

as a reference microphone (115);

- an amplifier (124) for generating a loudspeaker driving signal;
- a microprocessor (126) configured to compare the signal level measured by the measurement microphone (114) and the reference microphone (115) and converted by a dual-channel A/D converter (123);

- a loudspeaker assembly (120) mounted in a second housing element (102) connected with the first housing element (101) and comprising a loudspeaker (135) for generating sound;
- a springy connector (131) installed inside the outdoor microphone housing elements (101, 102) for connecting the loudspeaker assembly (120) with the microphone assembly (110) to conduct the loudspeaker driving signal;
- wherein the first housing element (101) has openings (1011) surrounding an open sound cavity for passing ambient sound from the environment and the sound from the loudspeaker assembly (120) located at one end of the cavity to the microphone assembly (110) located at the other end of the cavity.

2. The microphone according to claim 1, comprising a pair or more of measurement microphones (114) and a pair or more of reference microphones (115).

3. The microphone according to claim 2, wherein the reference microphones (115) have a different characteristics, preferably a narrower measurement band, than the measurement microphones (114).

4. The microphone according to any of previous claims, further comprising:

- an amplifier (124) controlled by a microprocessor (126);
- wherein the amplifier (124) is configured to generate the loudspeaker driving signal;
- and wherein the microprocessor (126) is configured to detect a difference between the signal level measured by the measurement microphone (114) and the reference microphone (115) and to generate a positive system check result signal if the difference is below a threshold and a negative system check result signal otherwise.

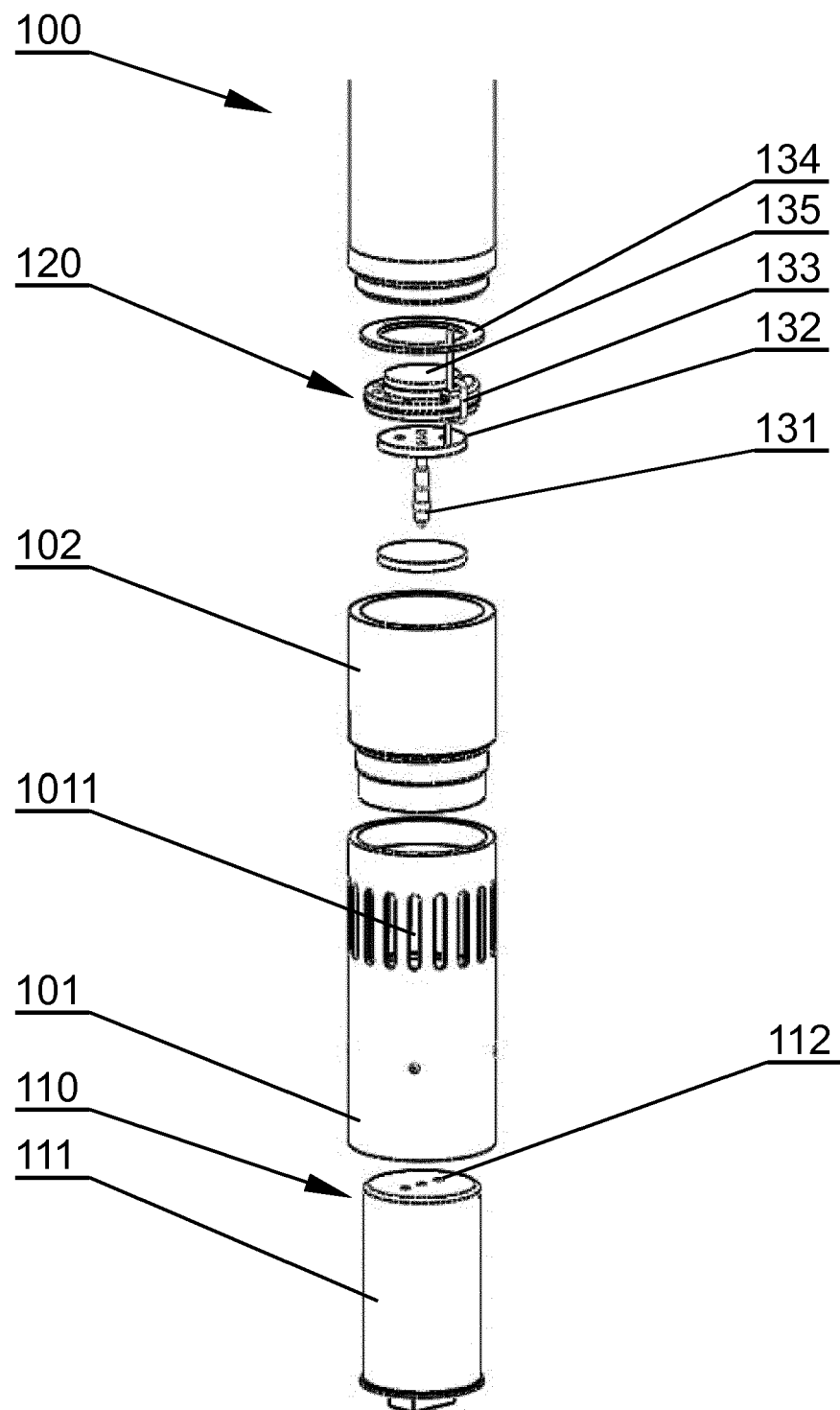


Fig. 1A

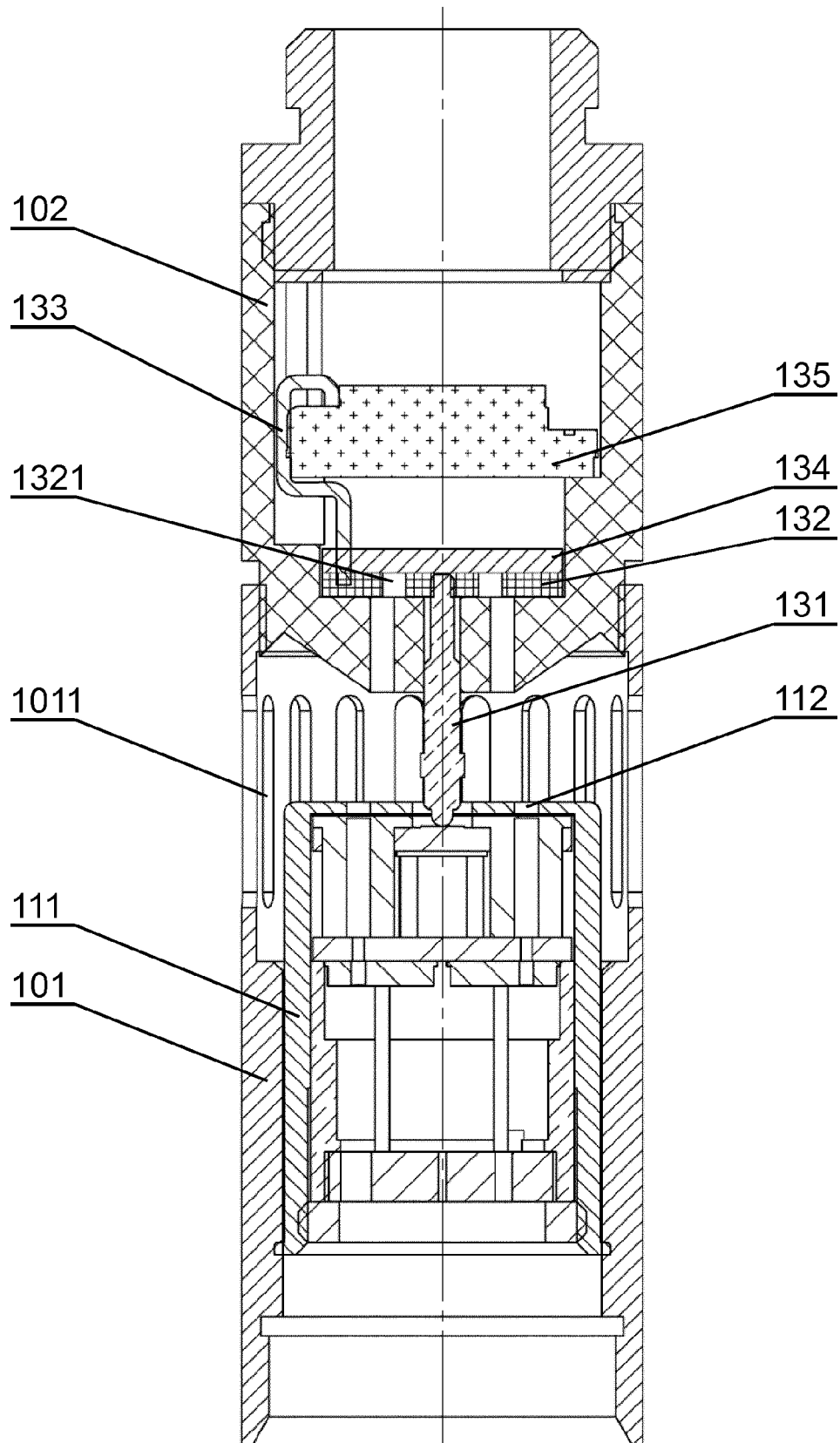


Fig. 1B

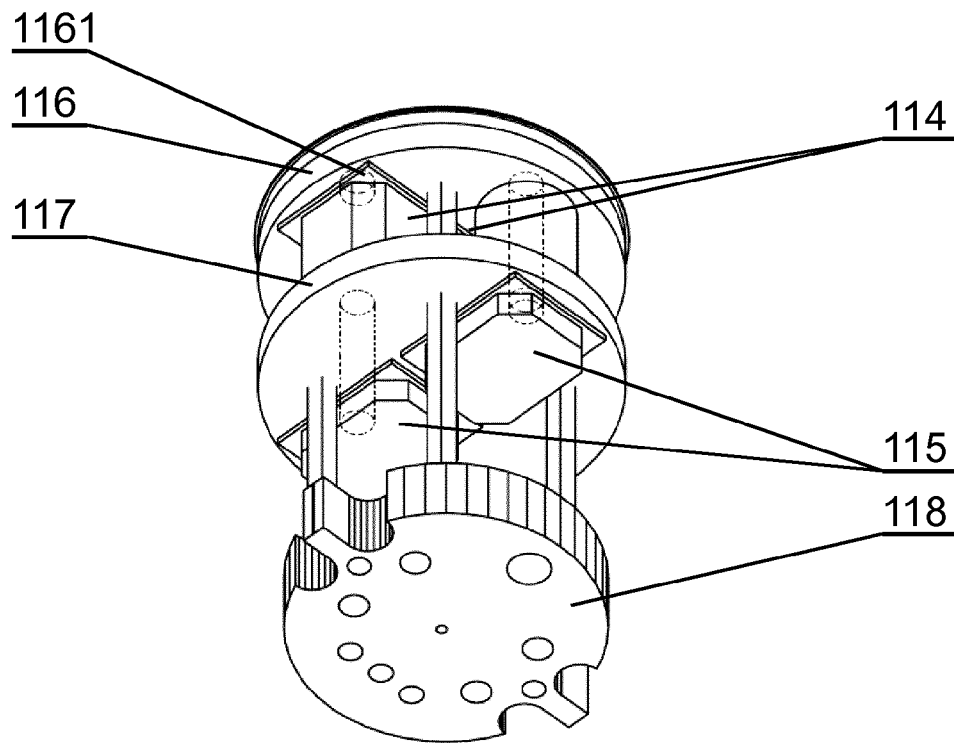


Fig. 2A

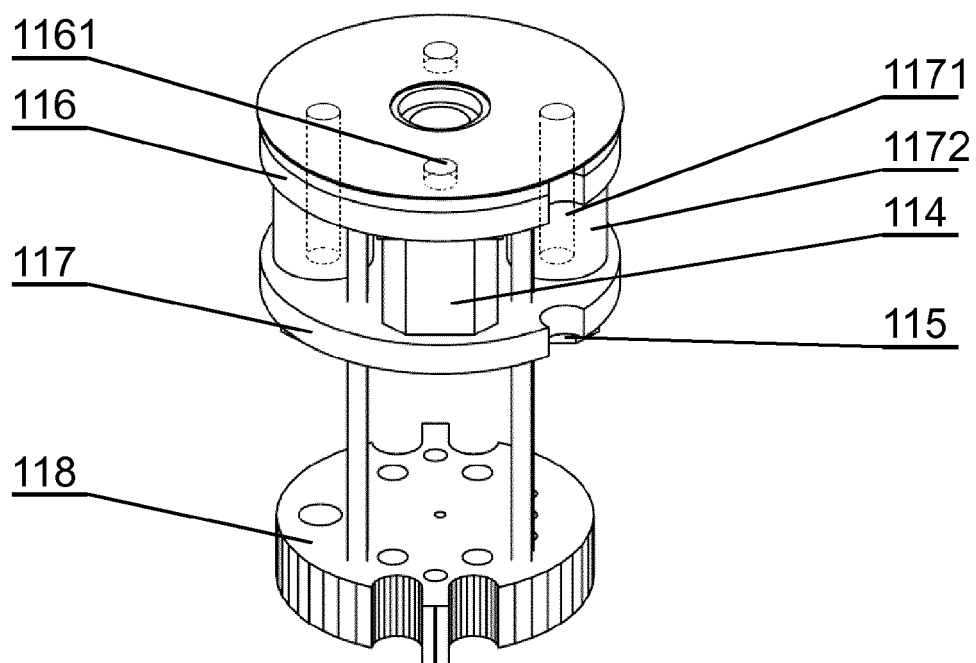


Fig. 2B

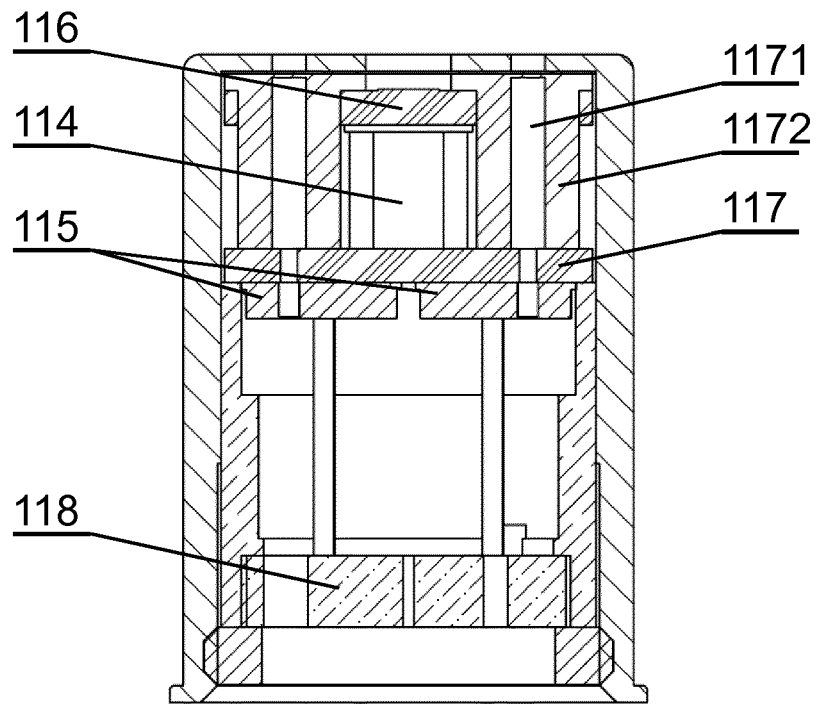


Fig. 2C

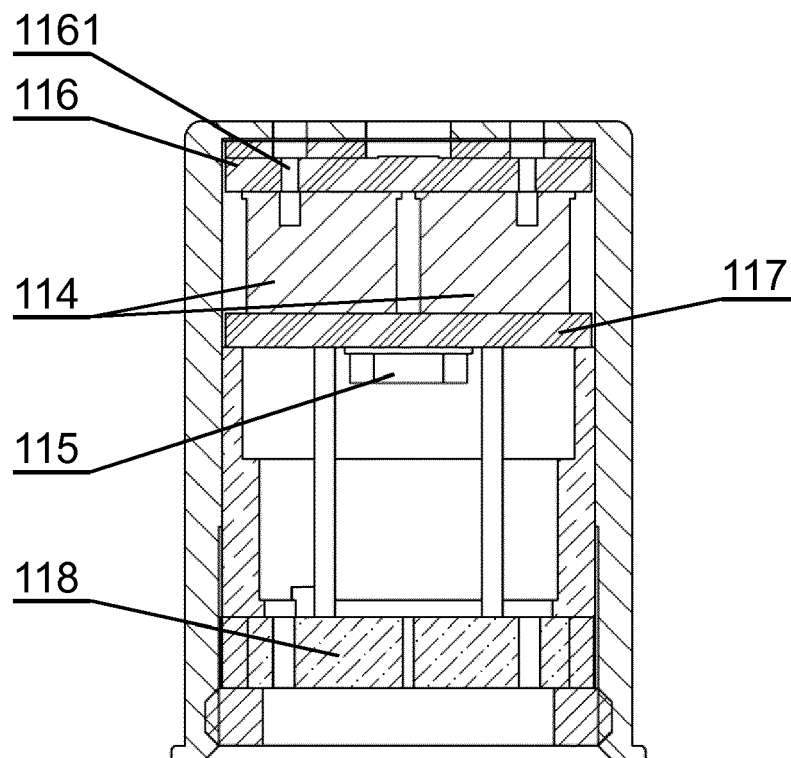


Fig. 2D

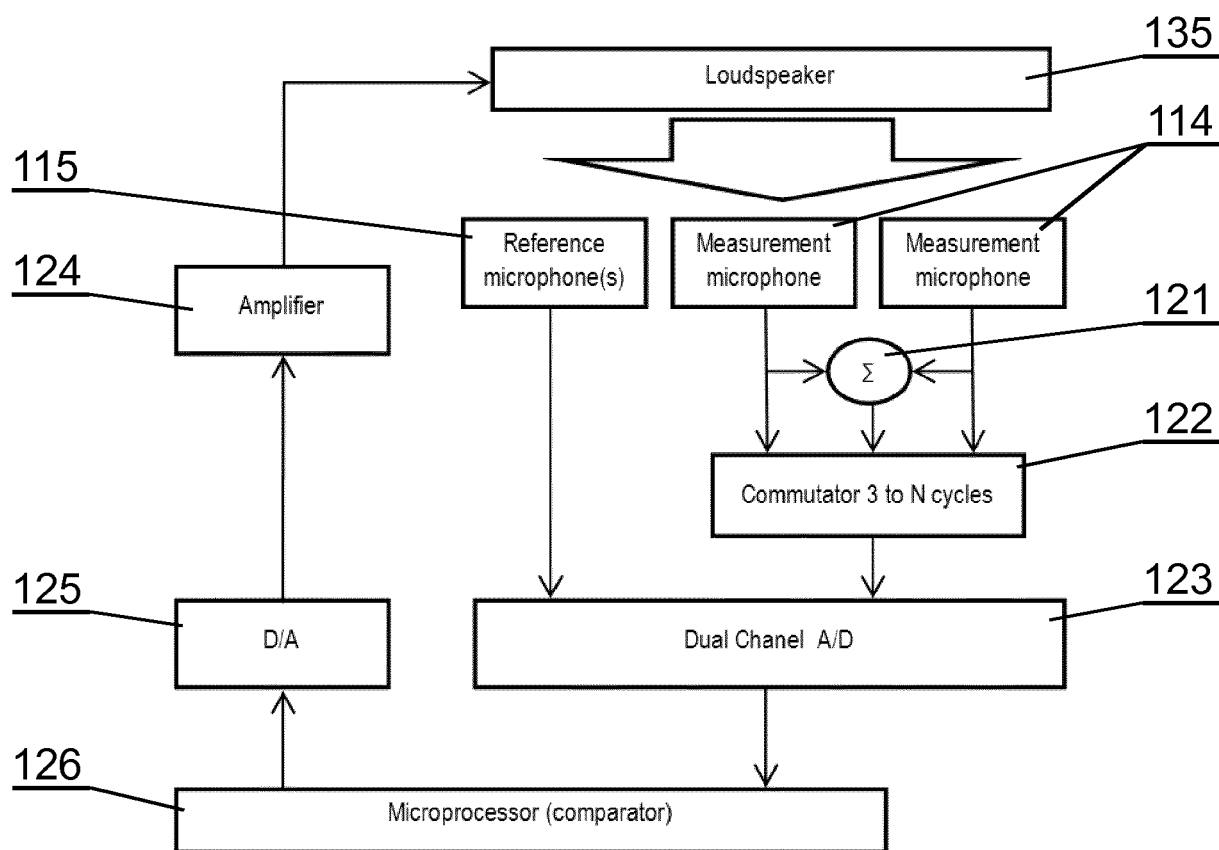


Fig. 3



EUROPEAN SEARCH REPORT

 Application Number
 EP 16 46 1510

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 21 September 2016	Examiner Carrière, Olivier
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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