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(54) Title: SPEAKER AND METHOD FOR DISPLACEMENT MEASUREMENT

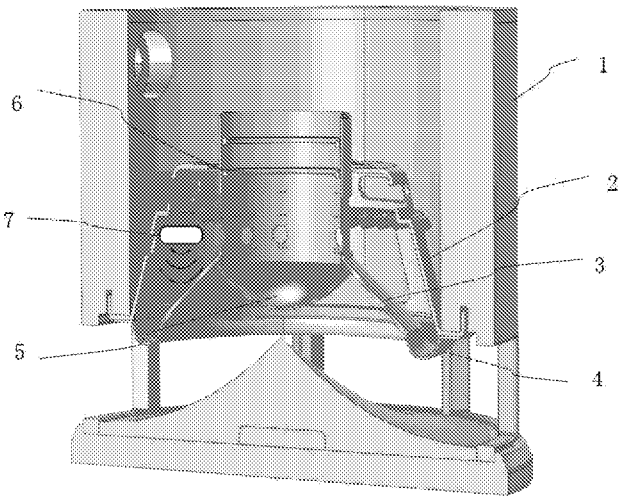

FIG. 1

(57) Abstract: A speaker and a method for displacement measurement in a speaker unit are disclosed. The speaker comprises: a housing; a speaker unit mounted in the housing, which includes a moving part; and a radar sensor, which is placed by using a chosen stationary position of the speaker, wherein the radar sensor receives radar wave reflected by or transmitting through the moving part, and sends signals for the radar wave to an internal or external processing device so that the processing device processes the signals for the received radar wave from the radar sensor to calculate displacement of the moving part.

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SPEAKER AND METHOD FOR DISPLACEMENT MEASUREMENT

FIELD OF THE INVENTION

The present disclosure relates to the technical field of a loudspeaker.

BACKGROUND OF THE INVENTION

In recent years, several miniature radar systems have been marketed. Some of them have a radio frequency of several hundreds of GHz.

The moving parts in such as diaphragm of a speaker unit (or driver) in a speaker is vulnerable. So, the speaker shall work in its specified range; otherwise, it may be damaged. Generally, amanufacturermeasures the working range by using a professional equipment and setsthe working range. In such a case, the manufacturer shall provide a large redundancy for the speaker unit. Even though the speaker unit has such a redundancy,it is still possible that the speaker unit is damaged by an accident event such as a sharp noise.

SUMMARY OF THE INVENTION

One object of this invention is to provide a new technical solution fora speaker.

According to a first aspect of the present invention, there is provided a speaker, comprising: a housing; a speaker unit mounted in the housing, which includes a moving part; and a radar sensor, which is placed by using a chosen stationary position of the speaker, wherein the radar sensor receives radar wave reflected by or transmitting through the moving part, and sends signals for the radar wave to an internal or external processing device so that the processing device processes the signals for the received radar wave from the radar sensor to calculate displacement of the moving part.

According to a second aspect of the present invention, there is provided a method for displacement measurement in a speaker unit, comprising:choosing a stationary positionfor fixing a radar sensor inside or outside the speaker unit;placing the radar sensor by using the stationary position;receiving, by the radar sensor, radar wave reflected by or transmitting through the

moving part; andprocessing, by a processing device, signals for the received radar wave from the radar sensor to calculate displacement of the moving part.

According to various embodiment of this disclosure,a new solution of displacement measurement in a speaker unit is provided.

Further features of the present invention and advantages thereof will become apparent from the following detailed description of exemplary embodiments according to the present invention with reference to the attached drawings.

BRIEF DISCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description thereof, serve to explain the principles of the invention.

Figures 1-8 are schematic views ofspeakers according to various embodiment of this disclosure.

Figure 9 is a block diagram of a speaker system.

Figure10 is a flow chart of a method for displacement measurement in a speaker unit according to an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various exemplary embodiments of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components and steps, the numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

The following description of at least one exemplary embodiment is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Techniques, methods and apparatus as known by one of ordinary skill in the relevant art may not be discussed in detail but are intended to be part of the specification where appropriate.

In all of the examples illustrated and discussed herein, any specific values should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it is possible that it need not be further discussed for following figures.

Several miniature radar systems are available. Some of them have a radio frequency of several hundreds of GHz. We have found that the wavelength of the radar systems is small enough to provide an accurate displacement measurement. On the other hand, many the radar systems are small enough to be mounted inside the back cavity of a speaker.

In view of the above, we propose to use a small radar sensor for measurement of the displacement and/or velocity of moving part such as a diaphragm of a speaker unit. The sensor is directed towards a moving part such as a diaphragm of the speaker unit, to continuously monitor the motion and displacement of the moving part. The information from the radar sensor can be used by audio processing unit, for the purposes such as speaker protection, improvement of sound reproduction and echo cancellation.

Here, a small radar sensor is placed in a speaker for measurement of the displacement and/or velocity of the diaphragm of a speaker unit.

Figures 1-8 are schematic views of speakers according to various embodiment of this disclosure.

In Figure 1, a cross-section view of a speaker is shown. The speaker has a housing 1 and a speaker unit mounted in the housing 1. The speaker unit may include a basket 2 which contains other components of the speaker unit; a diaphragm 3; a surrounding 4; a dust cap 5; coil former 6. These components could be those usually used in a speaker unit and thus the detailed description thereof is omitted.

The speaker unit includes a moving part, which can move when the unit produces sound. The moving part is, for example, the diaphragm 3 or the dust cap 5.

As shown in Figure 1, a radar sensor 7 is placed by using a chosen stationary position of the speaker.

In Figure 1, the moving part is a diaphragm 5 of the speaker unit and the stationary positionis a position in a space between a basket 2 of the speaker unit and the diaphragm 5.

The radar sensor 7 receives radar wave reflected by or transmitting through the moving part, and sends signals for the radar wave to an internal or external processing device so that the processing device processes the signals for the received radar wave from the radar sensor 7 to calculate displacement of the moving part.

In this disclosure, the radar sensor is incorporated into the speaker unit and can monitor the status of its moving parts in real time. As such, the processing device can obtain the information of the speaker unit and respond timely.

AsshowninFigures 1-8, the radar sensor is in line-of-sight to the moving part and faces the moving part.

Figure 2 shows another arrangement of the radar sensor 8. As show in Figure 2, the moving part is a dust cap 5 of the speaker unit. Here, the stationary positionis a position, which has a line in sight through at least one hole in a top plate 10 (in dash line) and/or a bottom plate 9(in dash line) of the speaker unit to a rear of the dust cap 5. The radar sensor 8 is placed on the bottom plate 9.

In Figure 3, the moving part is a diaphragm 3 of the speaker unit and the stationary positionis a position behind a basket 2 of the speaker unit pointing towards the diaphragm through at least one hole in the basket. As shown in Figure 3, the radar sensor 11 is placed at the position behind the basket 2. Because the air flow vibration is normally stronger in the basket 2 than that outside the basket 2, placing the radar sensor 11 behind the basket 2 will reduce this influence at least to some degree, compared with the position near the moving parts.

In Figure 4, the moving part is a diaphragm 3 or a dust cap 5 of the speaker unit and the stationary positionis a position in front of the diaphragm or the dust cap in a way that does not interfere with airflow for the speaker unit. As shown in Figure 4, the radar sensor is placed on the center of the cover 20. In Figure 4, the airflow of the sound goes through the side channels of the cover 20, and the radar sensor 12 in the middle of the cover 20 will not interfere with the airflow.

In Figure 5, the stationary positionis a position at a pole piece 13 of a magnet system of the speaker unit. The radar sensor 14 is placed in the pole piece 13.

In Figure 6, the stationary positionis a position external to the speaker unit, such as in the housing 1. The radar sensor 14 is fixed in the housing 1. This will provide a stable base for the radar sensor and reduce the influence of potential movement of the radar sensor 14.

In Figure 7, the radar sensor 16 is placed at the stationary position through a support element 17. The support element 17 has at least two branches, which are not parallel and are radial from the radar sensor 16. The at least two branches of the support element 17 are arranged in a plane which has a projection plane parallel with a vibration direction of the moving part.

In Figure 7,the radar sensor 16 is placed in the pole piece 13ata position at an inner surface of a hollow structure inside the pole piece13 and at a lower end of the pole piece 13 close to a diaphragm of the speaker unit. The moving part is an inner surface of a coil former 6 of the speaker unit. The radar sensor 16 is placed inside the hollow structure through a support element16 and is arranged to facethe inner surface of the coil former 6.

This would provide a stable support for the radar sensor and also provide a freedom of design for arranging the radar sensor.

Alternatively, the radar sensor16 can be placed with a part of the radar sensor 16 pressing against the lower end of the pole piece 13 so as to provide a more stable support.

In Figure 8,the radar sensor 18 is placed at aposition at a basket of the speaker unit, whichis a fixing part 19 of the basket of the speaker unit. The fixing part19 is used for fixing the speaker unit on the housing. Furthermore, the fixing part 19 of the basket is an upper surface or a lower surface of a part of the basket 2 where a bolt hole 19 is located. This would enhance the stableness of the radar sensor and provide more accurate measurement.

As shown in Figure 8, the radar sensor 18 is arranged in a tilt direction to face the moving part.

Here, the radar wave is of radio frequency. For example, the frequency of the radar wave is above 100 GHz.

Figure 9 shows a block diagram of a speaker system. As shown in Figure 9, a speaker 92 is connected to a processing device 91. For example, the information obtained by the radar sensor in the speaker 92 will be processed in the processing device 91. For example, the processing device 91 determines the status of the speaker 91 according to the information and control the speaker accordingly.

Figure10 is a flow chart of a method for displacement measurement in a speaker unit according to an embodiment.

As shown in Figure 10, at step, S92, a stationary positionfor fixing a radar sensor inside or outside the speaker unit is chosen.

At step S94, the radar sensor by using the stationary position is placed.

At step S96, radar wave reflected by or transmitting through the moving part is received by the radar sensor.

At step S98, signals for the received radar wave from the radar sensor to calculate displacement of the moving part is processed by a processing device.

The radar sensor is in line-of-sight to a moving part of the speaker unit and faces the moving part.

For example,the moving part is a diaphragm of the speaker unit and choosing a stationary positioncomprises: choosing a position in a space between a basket of the speaker unit and the diaphragm, as the stationary position.

For example,the moving part is the dust cap or rear side of the diaphragm of the speaker unit, and choosing a stationary positioncomprises: choosing a position, which has a line-of-sight through at least one hole in a top plate and/or a bottom plate of the speaker unit to a rear of the dust cap or rear side of the diaphragm, as the stationary position.

For example,the moving part is a diaphragm of the speaker unit and choosing a stationary positioncomprises: choosing a position behind a basket of the speaker unit pointing towards the diaphragm through at least one hole in the basket, as the stationary position.

For example,the moving part is a diaphragm or a dust cap of the speaker unit and choosing a stationary positioncomprises: choosing a position in front of the diaphragm or the dust cap in a way that does not interfere with airflow for the speaker unit, as the stationary position.

For example,choosing a stationary positioncomprises: choosing at least one of the following positions as the stationary position: a position at a pole piece of a magnet system of the speaker unit, a position at a basket of the speaker unitand a position external to the speaker unit.

For example, choosing a stationary positionfurther comprises:choosing a fixing part of the basket of the speaker unit as the stationary position, which is used for fixing the speaker unit on a housing.

For example,choosing a fixing part of the basket of the speaker unit as the stationary position further comprises:choosing an upper surface or a lower surface of a part of the basket where a bolt hole is located, as the fixing part of the basket.

For example,choosing a stationary positionfurther comprises: choosing a position on an external housing for the speaker unit as the stationary position.

For example,lacing a radar sensor further comprises: forminga support element; andsetting one end of the support element to attach the stationary position and the other end of the support element connecting with the radar sensor.

For example,the forminga support element comprises:forming the support element with at least two branches which are not parallel and are radial from the radar sensor.

For example,forminga support element further comprises:arranging the at least two branches of the support element in a plane which has a projection plane parallel with a vibration direction of the moving part.

For example, placing a radar sensor further comprises:placing the radar sensor in a tilt direction to face the moving part.

For example,placing a radar sensor further comprises:placing the radar sensor in a cavity of thespeaker unit remote to terminals of the speaker unit.

For example,the position at the pole piece is a position at an inner surface of a hollow structure inside the pole piece and at a lower end of the pole piece closeto a diaphragm of the speaker unit, and the moving part is an inner surface of a coil former of the speaker unit. For example,placing a radar sensor at the stationary positionfurther comprises: placing the radar sensor inside the hollow structure of the pole piece through the support element and arranging the radar sensor to face the inner surface of the coil former.

For example,placing a radar sensor at the stationary positionfurther comprises: arranging the radar sensor with a part of the radar sensor pressing against the lower end of the pole piece.

The method may further comprises:choosing the moving part to be a coil of the speaker unit; and/orchoosing the moving part to be an inner surface of a coil former of the speaker unit; and/orchoosing the moving part to be an outer surface of a coil former of the speaker unit, which is at a lower part of the coil former, and the lower part is close to a diaphragm of the speaker unit; and/orchoosing the moving part to be a front surface of a diaphragm of the speaker unit, or to be an inner surface of the diaphragm of the speaker unit. For example,the receiving, by the radar sensor, radar wave reflected by or transmitting through the moving part comprises:receiving, by the radar sensor, radar wave reflected by or transmitting through a preset area of the coil,the coil former and/or the diaphragm.

For example, an emitter for emitting the radar wave is located at the same place as the radar sensor, or is located at a separate place from that of the radar sensor and the radar wave can be reflected or transmitted to the radar sensor.

For example, an emitter for emitting the radar wave is integrated with the radar sensor.

Although some specific embodiments of the present invention have been demonstrated in detail with examples, it should be understood bya personskilled in the art that the above examples are only intended to be illustrative but not to limit the scope of the present invention.

CLAIMS

1. A speaker, comprising:

a housing;

a speaker unit mounted in the housing, which includes a moving part; and

aradar sensor, which is placed by using a chosen stationary position of the speaker, wherein the radar sensor receives radar wave reflected by or transmitting through the moving part, and sends signals for the radar wave to an internal or external processing device so that the processing device processes the signals for the received radar wave from the radar sensor to calculate displacement of the moving part.

2. The speaker according to claim 1, wherein the radar sensor is in line-of-sight to the moving part and faces the moving part.

3. The speaker according to claim 1 or 2, whereinthe moving part is a diaphragm of the speaker unit and the stationary positionis a position in a space between a basket of the speaker unit and the diaphragm.

4. The speaker according to claim 1 or 2, whereinthe moving part is a dust cap of the speaker unit, and the stationary positionis a position, which has a line in sight through at least one hole in a top plate and/or a bottom plate of the speaker unit to a rear of the dust cap.

5. The speaker according to claim 1 or 2, whereinthe moving part is a diaphragm of the speaker unit and the stationary positionis a position behind a basket of the speaker unit pointing towards the diaphragm through at least one hole in the basket.

6. The speaker according to claim 1 or 2, whereinthe moving part is a diaphragm or a dust cap of the speaker unit and the stationary positionis a position in front of the diaphragm or the dust cap in a way that does not interfere with airflow for the speaker unit.

7. The speaker according to claim 1 or 2, wherein the radar sensor is placed at the stationary position through a support element;

the support element has at least two branches, which are not parallel and are radial from the radar sensor;

wherein the at least two branches of the support element are arranged in a plane which has a projection plane parallel with a vibration direction of the moving part.

8. The speaker according to claim 1 or 2, wherein the stationary positionis a position at an inner surface of a hollow structure inside a pole piece of a magnet system of the speaker unit and at a lower end of the pole piece close to a diaphragm of the speaker unit, and the moving part is an inner surface of a coil former of the speaker unit;

wherein the radar sensoris placed inside the hollow structure through a support element and is arranged to facethe inner surface of the coil former.

9. The speaker according to claim 1 or 2,wherein the radar sensor is placed with a part of the radar sensor pressing against the lower end of the pole piece.

10. A method for displacement measurement in a speaker unit, comprising:

choosing a stationary positionfor fixing a radar sensor inside or outside the speaker unit;

placing the radar sensor by using the stationary position;

receiving, by the radar sensor, radar wave reflected by or transmitting through the moving part; and

processing, by a processing device, signals for the received radar wave from the radar sensor to calculate displacement of the moving part.

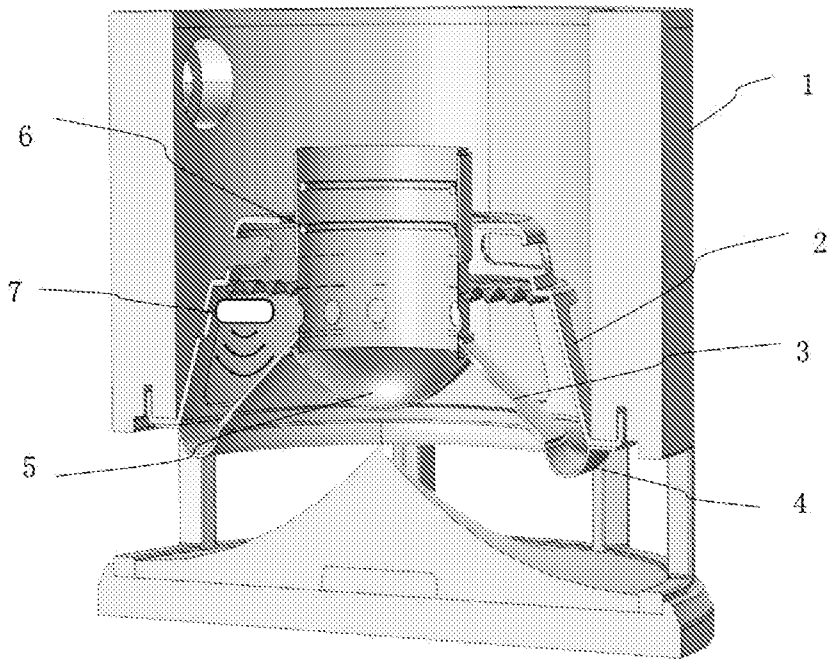

FIG. 1

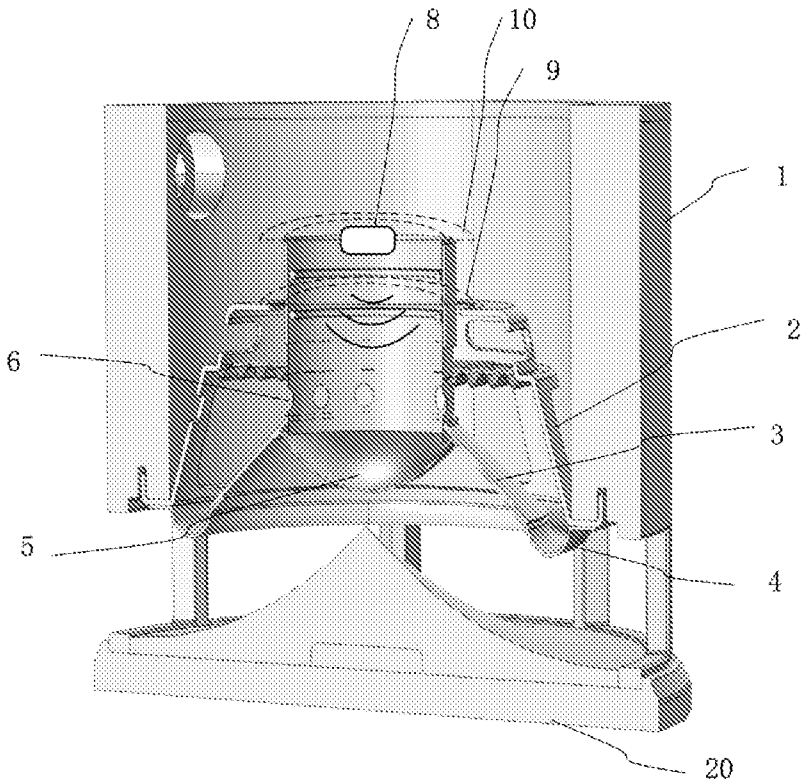

FIG. 2

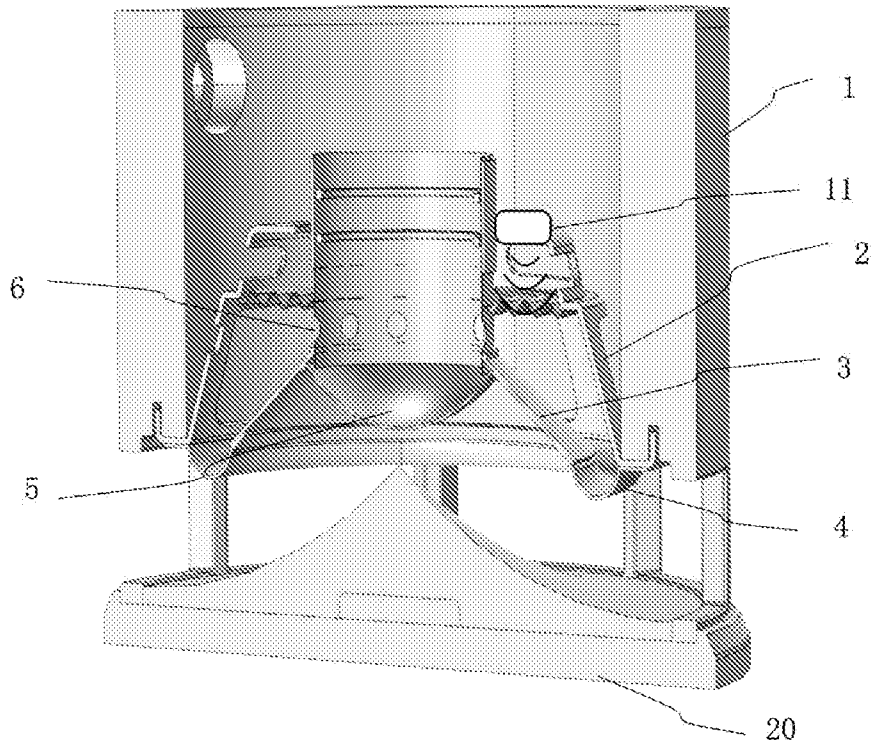

FIG. 3

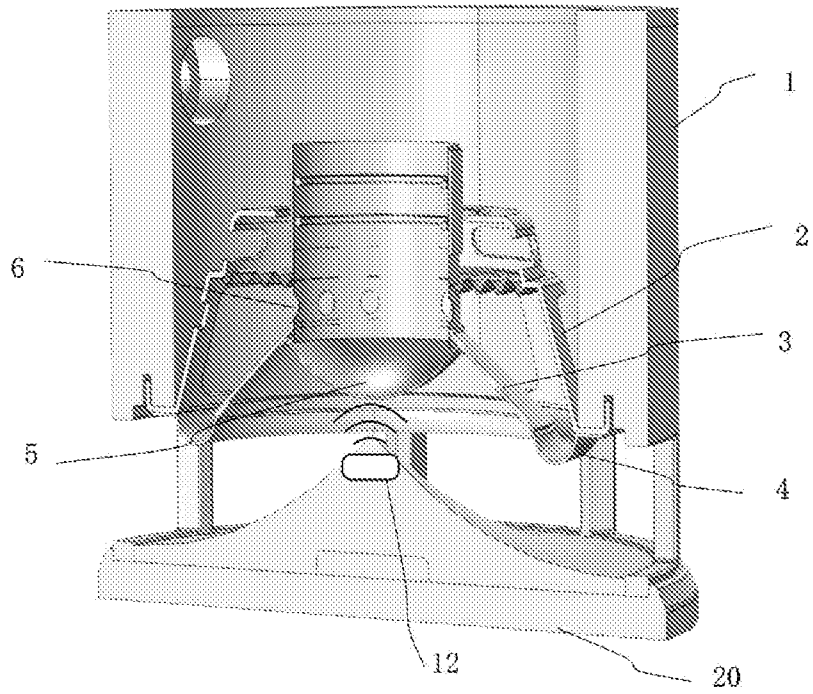

FIG. 4

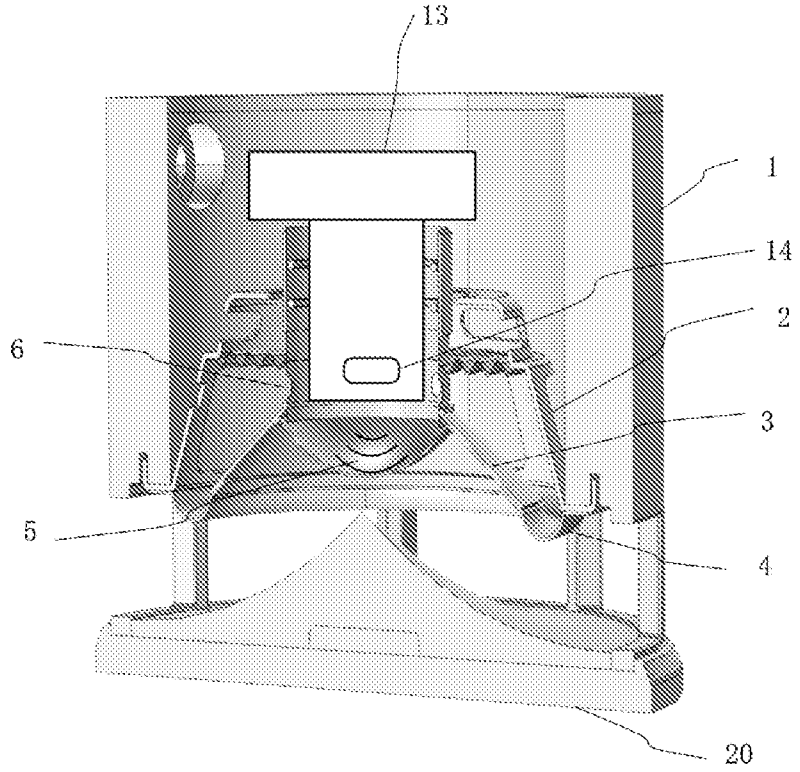

FIG. 5

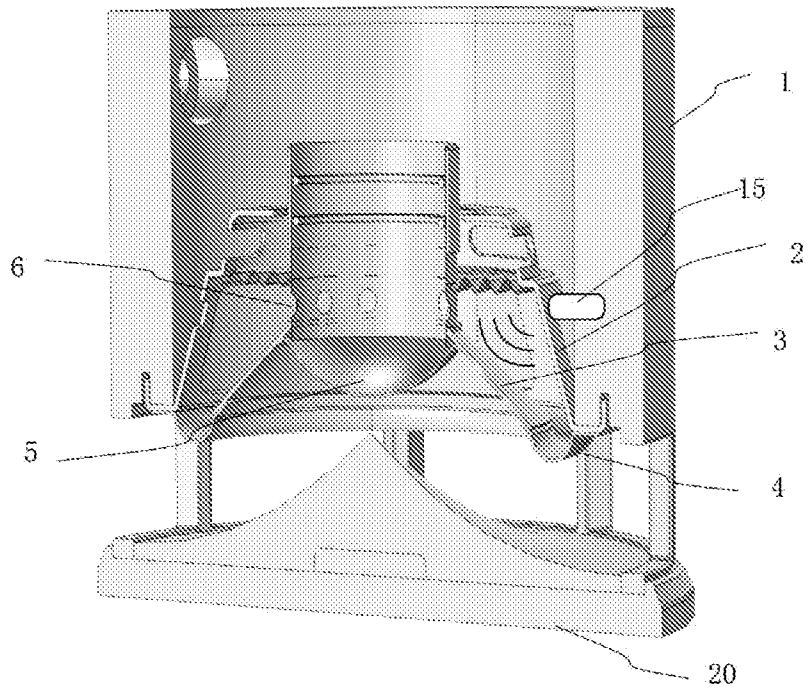

FIG. 6

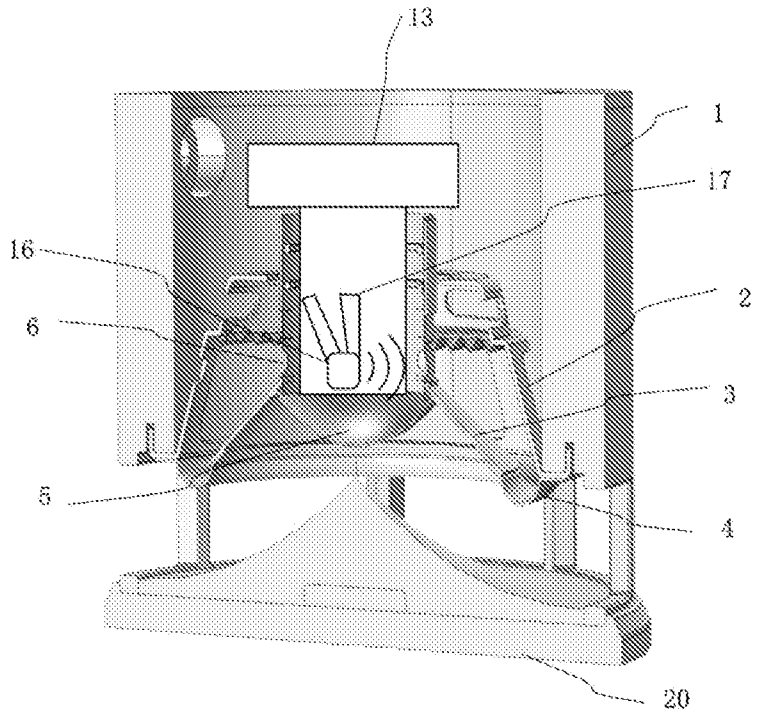

FIG. 7

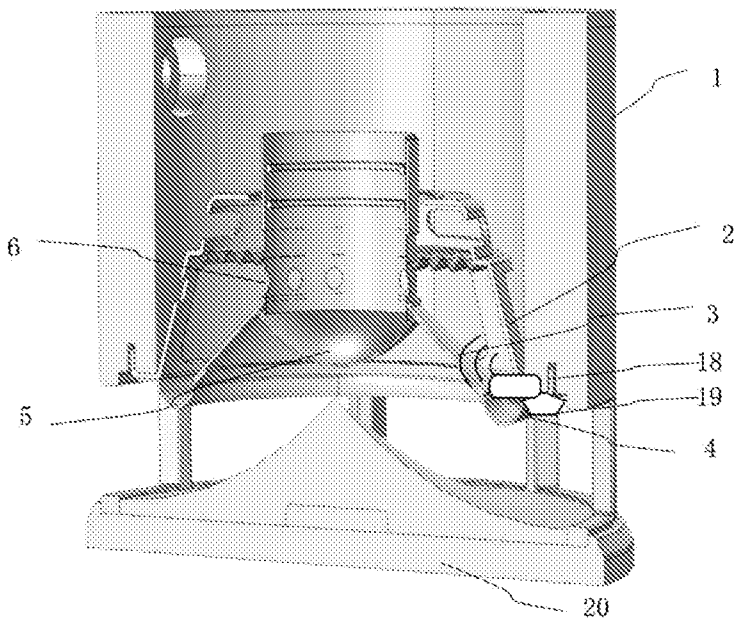

FIG. 8

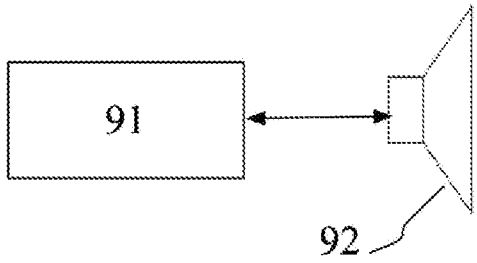
91
92

FIG. 9

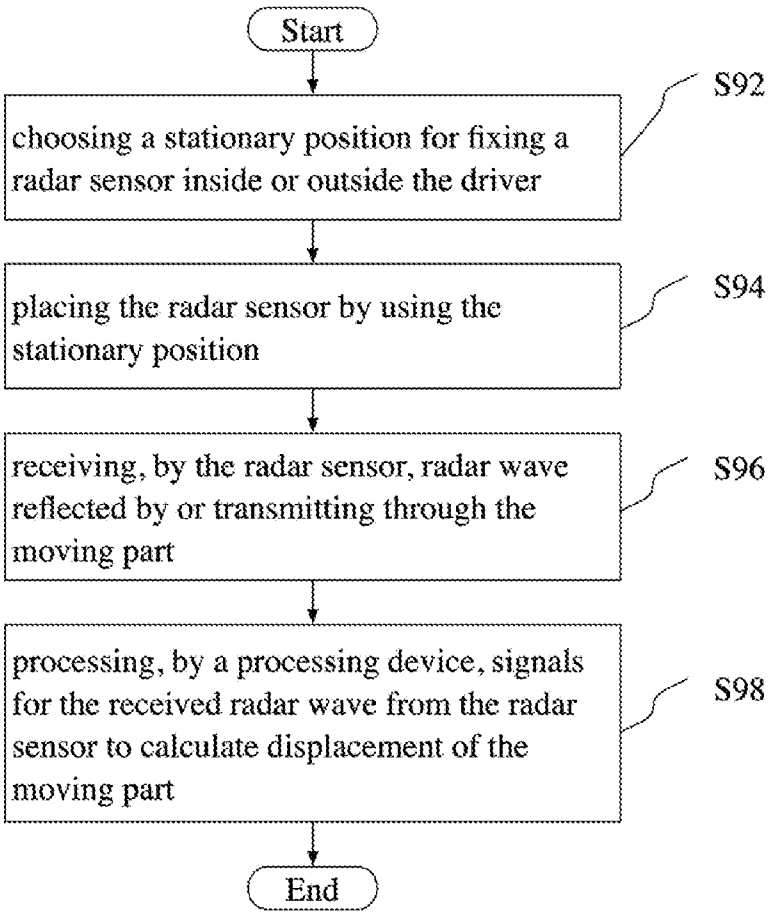
Start
choosing a stationary position for fixing a radar sensor inside or outside the driver
S92
placing the radar sensor by using the stationary position
S94
receiving, by the radar sensor, radar wave reflected by or transmitting through the moving part
S96
processing, by a processing device, signals for the received radar wave from the radar sensor to calculate displacement of the moving part
S98
End

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/128821

A. CLASSIFICATION OF SUBJECT MATTER

H04R 29/00(2006.01)i

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)

H04R

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 practicable, search terms used)

VEN;CNABS;WOTXT;EPTXT;USTXT;CNTXT;CNKI:speaker?, hous+, diaphragm, mov+, radar, sesor+, detect+, monitor+, displac+, replac+, dust, cap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 9820067 B2 (AAC TECHNOLOGIES PTE LTD) 14 November 2017 (2017-11-14) the abstract, claim 1, line 46 of column 1 to line 61 of column 2 in the description	1-10
A	EP 1727392 A2 (PIONEER CORP et al.) 29 November 2006 (2006-11-29) the whole document	1-10
A	CN 1207011 A (Zhang, Fan) 03 February 1999 (1999-02-03) the whole document	1-10

☐ 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" earlier application or patent 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
25 February 2020	**11 March 2020**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**SUN,Chengyu**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(010)-62089394**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/128821

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	9820067	B2	14 November 2017	US	2017013380	A1	12 January 2017
				CN	204887416	U	16 December 2015
EP	1727392	A2	29 November 2006	US	2006274914	A1	07 December 2006
				US	7961902	B2	14 June 2011
CN	1207011	A	03 February 1999	CN	1115943	C	23 July 2003