(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 519 617 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.03.2005 Bulletin 2005/13

(51) Int Cl.[7]: **H04R 1/28**

(21) Application number: **04255080.6**

(22) Date of filing: **24.08.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(30) Priority: **25.09.2003 JP 2003333523**

(71) Applicants:
- **Pioneer Corporation**
  Tokyo 153-8654 (JP)
- **Tohoku Pioneer Corporation**
  Tendo-shi, Yamagata 994-8585 (JP)

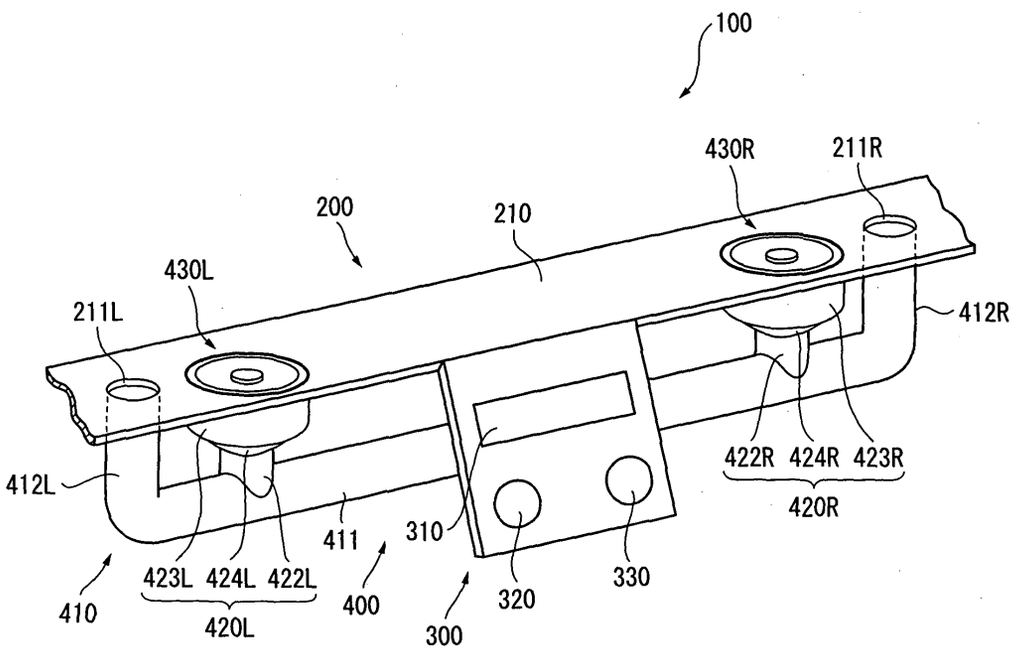
(72) Inventors:
- **Kitamura, Ichio, c/o Pioneer Corporation**
  Tokyo 153-8654 (JP)
- **Oonuma, Tetsuya, c/o Tohoku Pioneer Corp.**
  Tendo-shi, Yamagata 994-8585 (JP)
- **Inohana, Haruyuki, c/o Pioneer Corporation**
  Kawagoe-shi, Saitama 350-8555 (JP)

(74) Representative: **Haley, Stephen**
Gill Jennings & Every,
Broadgate House,
7 Eldon Street
London EC2M 7LH (GB)

(54) Acoustic device

(57) An acoustic device (400), which is mounted on an instrument panel (100) with a built-in reinforcement (410) having a hollow portion, comprises speaker mounting members (420L and 420R), each having a hollow portion, a base end of which is communicated with the reinforcement (410), and speakers (430L and 430R) disposed in the openings at the front end side of the speaker mounting members (420L and 420R), which emit sounds outside the instrument panel (100). It is arranged so that the hollow portions of the reinforcement (410) and the hollow portions of the speaker mounting members (420L and 420R) function as the resonant sections for allowing the sounds emitted by the speakers (430L and 430R) to resonate.

FIG. 2



EP 1 519 617 A2

Description

[0001] The present invention relates to, for example, an acoustic device, which is mounted on a structural body with a built-in reinforcing member having a hollow portion.

[0002] Conventionally, acoustic devices, which are disposed on automobiles, are known. In an automobile with limited compartment space, to have a wider space, such arrangement that acoustic device, which is disposed in the door section, is known (for example, reference document; Japanese Unexamined Utility Model Publication No. 7-33089).

[0003] In the arrangement disclosed in the above reference document, the door section is provided with a speaker and a speaker mounting section for holding the speaker, which has a substantially hollow truncated cone shape. The speaker is used for mainly reproducing deep sounds; and the larger is diameter thereof, the more capacity of reproducing deep sounds is improved.

[0004] However, although a larger diameter of the speaker increases the capacity of reproducing deep sounds, it increases the cost and the weight of the speaker. Accordingly, in a compact car such as, for example, a 1-liter vehicle, which has a strict limitation in the cost and weight, there resides such problem that, for example, a speaker of 14 cm or 16 cm diameter providing a high capacity of reproducing deep sounds is hardly employed. Further, when the speaker is disposed in the door section, waterproof covers for the speakers are required. Accordingly, there resides another problem such that the weight of the automobile is increased.

[0005] An object of the present invention is to provide an acoustic device capable of reproducing deep sounds as well as reducing the cost and the weight thereof.

[0006] An acoustic device according to the present invention is mounted on a structural body with a built-in reinforcing member having a hollow portion therein, and provided with a speaker for emitting sounds outside the structural body, and a speaker mounting member for disposing the speaker at the front end side thereof, a base end of which is communicated with the reinforcing member, and the acoustic device is characterized in that the speaker mounting member includes a hollow portion communicated with a hollow portion of the reinforcing member, and the hollow portions function as a resonant section for allowing the sounds emitted from the speaker to resonate.

[0007] In the Drawings;

Fig. 1 is a plan view of an automobile disposed with an acoustic device according to a present embodiment ;

Fig. 2 is a perspective view showing disposition of the acoustic device according to the present embodiment;

Fig. 3 is a partially sectional perspective view showing rough configuration of the acoustic device according to the present embodiment;

Fig. 4 is a block diagram showing the rough configuration of a measuring system used for an experiment for verifying the effect of the embodiment;

Fig. 5 is a perspective view showing rough configuration of the acoustic device in the experiment;

Fig. 6 is a cross sectional view showing a rough configuration of the acoustic device in the experiment; and

Fig. 7 is a graph showing an evaluation result of the experiment.

[0008] Hereinafter, an embodiment of the present invention will be described with reference to the drawings. Fig. 1 is a plan view showing an automobile provided with an acoustic device according to a present embodiment. Fig. 2 is a perspective view showing a disposition of the acoustic device. Fig. 3 is a partially sectional perspective view showing rough configuration of the acoustic device.

[Configuration of the acoustic device]

[0009] In Fig. 1, reference numeral 1 denotes an automobile as a movable body. The automobile 1 comprises an instrument panel 100 and the like as a structural body. The instrument panel 100 comprises, as shown in Fig. 2, a main body 200, an operation display 300, an acoustic device 400, a controller (not shown in the drawing), and the like.

[0010] The main body 200 is formed, for example, in a configuration such that a substantially flat plate resin material is bent into a substantially squared U-like shape in section (not shown in the drawing). The main body 200 is disposed in a compartment of the automobile 1 so that the substantially squared U-like shape opening is positioned at the front side of the automobile 1. The main body 200 comprises an upper portion 210, and a front portion and a lower portion, which are not shown in the figure.

[0011] The upper portion 210 is formed in a substantially elongated rectangular shape. Hereinafter, descriptions will be made based on the following definitions; i. e., one end in the longitudinal direction of the upper portion 210 is the left end; the other end in the longitudinal direction is the right end; and the substantially central area in the longitudinal direction is the central area. The upper portion 210 is formed with reinforcement holes 211 L and 211 R, and two speaker holes (not shown).

[0012] The reinforcement hole 211 L is formed in the vicinity of the left end of the upper portion 210. The reinforcement hole 211L is formed in a substantially circular shape, which has a diameter substantially equal to the diameter of a duct section 412L of a reinforcement 410 on the acoustic device 400. The reinforcement hole 211R is formed in the vicinity of the right end of the upper portion 210. The reinforcement hole 211 R is formed in substantially the same shape as that of the reinforce-

ment hole 211 L.

[0013] The speaker holes are respectively disposed in the area of the upper portion 210 inner than the reinforcement holes 211 L and 211 R adjacent thereto. The respective speaker holes are formed in a substantially circular shape having a diameter substantially equal to the diameter of a speaker 430 of the acoustic device 400, which will be described later. Also, in the vicinity of these speaker holes, screw holes (not shown), in which screws (not shown) for mounting the speakers 430 are screwed, are formed.

[0014] The front portion includes a disposition part, air conditioning outlets and the like which are not shown. In the disposition part, the operation display 300, and not shown components such as various switches for air conditioning etc. and instruments for indicating the engine speed and the speed of the automobile and the like are disposed.

[0015] The operation display 300 is, as described above, disposed in the not shown disposition part on the front portion of the main body 200. And the operation display 300 comprises a display 310, a tuning knob 320, a volume knob 330 and the like.

[0016] The display 310 is formed in a substantially rectangular shape. The display 310 is disposed in the substantially front-central area of the operation display 300. The display 310 displays the frequency of the radio and the volume emitted from the acoustic device 400, and the like. As for the display 310, for example, a liquid crystal or an organic EL (Electro Luminescence) panel or the like is available.

[0017] The tuning knob 320 is formed of, for example, a material such as a plastic in a substantially cylinder shape. The tuning knob 320 is disposed in the front left-lower portion of the operation display 300 rotatably in the circumferential direction thereof.

[0018] The volume knob 330 is formed of the same member as that for the tuning knob 320. The volume knob 330 is disposed in the front right-lower portion of the operation display 300 rotatably in the circumferential direction thereof.

[0019] The layout, material, shape and the like of the display 310, the tuning knob 320 and the volume knob 330 are not limited to the above-described arrangement, but an appropriate arrangement may be employed. Also, the tuning knob 320 and the volume knob 330 may be constituted of the same members.

[0020] The controller is connected to the display 310, the tuning knob 320, the volume knob 330, the acoustic device 400, and the like. When the tuning knob 320, the volume knob 330 or the like is operated, the controller controls the operation of the display 310, the acoustic device 400 or the like. Specifically, when the tuning knob 320 or the volume knob 330 is operated, the controller controls the display 310 and displays various pieces of information on the display 310. Also, when the tuning knob 320 is operated, the controller varies the frequency of the radio received by an antenna (not shown). And the controller outputs signals corresponding to sounds of the radio, which is received by the antenna, and music or the like, which is reproduced by the above reproducing apparatus or the like, to the acoustic device 400. The acoustic device 400, which will be specifically described later, emits sounds corresponding to signals from the controller. Further, when the volume knob 330 is operated, the controller varies the magnitude of the output of the signals. Owing to this, the volume emitted from the acoustic device 400 is controlled.

[0021] The acoustic device 400 converts the signals, which are output from the controller, into sounds to emit the same therefrom. The acoustic device 400 comprises, as shown in Fig. 1 to Fig. 3, reinforcement 410, speaker mounting members 420L and 420R, speakers 430L and 430R, tweeters 440L and 440R and the like.

[0022] The reinforcement 410 is formed of a material such as a metal, which is hardly deformed by an external shock, into a substantially cylindrical shape. Here, it exemplifies a configuration in which the reinforcement 410 is formed into the substantially cylindrical shape. However, the configuration of the reinforcement 410 is not limited to the above. For example, an appropriate shape such as a tube having a substantially rectangular shape in section, or a tube having a substantially flat rectangular shape in section may be adopted. Further, the reinforcement 410 may be formed of short cylinders having the above respective shapes. The reinforcement 410 comprises a substantially straight reinforcement main body 411, and duct sections 412L and 412R, which are the both ends of the reinforcement main body 411 bent at substantially right angles respectively to form into a substantially squared U-like shape in its plane configuration. As shown in Fig. 3, provided in the substantially central portion in the axial direction of the reinforcement main body 411 is an anti-interference member 413, which is formed in an approximately disk-like shape. The anti-interference member 413 prevents interference of the sound waves, which pass through the hollow portion at one end side of the reinforcement main body 411, and the sound waves, which pass through the hollow portion at the other end side thereof. Here, an example of configuration in which the anti-interference member 413 is formed in a substantially disk-like shape is given. However, if the substantially central portion of the reinforcement main body 411 is closed, and a satisfactory thickness for preventing the interference of the sound waves is given, any configuration may be adopted. In the following description, the hollow portion of the reinforcement main body 411 at one end side from the anti-interference member 413 and the hollow portion of the duct section 412L will be referred to as a resonant section 414L; and the hollow portion of the reinforcement main body 411 at the other end side and the hollow portion of the duct section 412R will be referred to as a resonant section 414R.

[0023] The reinforcement 410 is a reinforcing member, which is disposed within the main body 200 to rein-

force the instrument panel 100. Specifically, the reinforcement 410 is disposed so that the axial direction of the reinforcement main body 411 is substantially parallel to the longitudinal direction of the upper portion 210 of the main body 200. And at the front-end portions of the duct sections 412L and 412R, the reinforcement 410 is joined to the circumference edges of the reinforcement holes 211 L and 211R respectively from the lower face of the upper portion 210. Owing to this, the resonant section 414L of the reinforcement main body 411 is communicated with the outside of the main body 200 via the reinforcement hole 211 L. Likewise, the resonant section 414R of the reinforcement main body 411 is communicated with the outside of the main body 200 via the reinforcement hole 211 R.

[0024] The speaker mounting members 420L and 420R are formed of the same material as that of the reinforcement 410 in a substantially cylindrical shape. Here, an example of a configuration, in which the speaker mounting members 420L and 420R are formed in a substantially cylindrical shape, is given. However, the configuration is not limited to the above. An appropriate shape such as, for example, a substantially rectangular tube, or a flat rectangular tube may be adopted. Also, the speaker mounting members 420L and 420R may be formed in a short cylindrical shape or the like. In the following descriptions, the hollow portion of the speaker mounting members 420L and 420R will be appropriately referred to as a resonant section 421L, 421R respectively. Each of the speaker mounting members 420L and 420R comprises base end portions 422L, 422R, which are formed in a cylindrical shape having an outer diameter substantially equal to the outer diameter of the reinforcement main body 411, front end portions 423L, 423R, which are formed in a cylindrical shape having an outer diameter larger than that of the reinforcement main body 411 so as to be fitted with the speaker 430L, 430R, and joint sections 424L, 424R connecting the base end portions 422L, 422R and the front end portions 423L, 423R therebetween.

[0025] The speaker mounting members 420L and 420R are, at the front end portions 423L and 423R, joined to the periphery edge of the speaker holes respectively from the lower face of the upper portion 210 so that the axial direction thereof are substantially parallel to the axial direction of the duct sections 412L and 412R, and joined to the circumferential surface of the reinforcement main body 411 at the base end portions 422L and 422R. Owing to this, the resonant section 421L of the speaker mounting member 420L is communicated with the outside of the main body 200 via the resonant section 414L of the reinforcement main body 411 and the speaker hole in the upper portion 210. Likewise, the resonant section 421R of the speaker mounting member 420R is communicated with the outside of the main body 200 via the resonant section 414R of the reinforcement main body 411 and the speaker hole in the upper portion 210. The speaker mounting members 420L and 420R may be formed integrally with the reinforcement 410, or may be manufactured separately from each other, and joined together with welding or the like.

[0026] The speakers 430L and 430R are speakers of, for example, 10 cm diameter covering full-range. Each of the speakers 430L and 430R comprises an oscillation generator 431L, 431R, an oscillator 432L, 432R and the like.

[0027] Each of the oscillation generators 431L and 431R converts signals, which are input from the controller, into oscillation and transmits the oscillation to the oscillator 432L, 432R respectively. Each of the oscillation generators 431 L and 431R comprises a case 433L, 433R, and not shown voice coil, a magnetic body and the like. The cases 433L and 433R are formed of a metal material and the like in a substantially cylindrical shape. The voice coils are connected to the controller via a conductor (not shown) respectively. Within each of the cases 433L and 433R, the voice coil and the magnetic body are arranged so that, when signals are input to the voice coil from the controller, oscillations corresponding to the input signals are transmitted to each of the oscillators 432L and 432R by the voice coil and the magnetic body respectively.

[0028] Each of the oscillators 432L and 432R comprises a frame 434L, 434R, a diaphragm 435L, 435R and the like respectively. The frame 434L, 434R holds the diaphragm 435L, 435R respectively. The frames 434L, 434R are formed in a substantially hollow truncated cone shape. In the following descriptions, in the substantially hollow truncated cone shape, the portion forming a circle with a smaller diameter will be referred to as bottom circumference forming section; and the portion forming the circle with a larger diameter will be referred to as upper circumference forming section. In the upper circumference forming section of the frame 434L, 434R, at the positions substantially opposite to each other interposed by the center of the upper circumference forming section, projections 436L, 436R projecting outward in the diameter direction are formed. In the projections 436L, 436R, screw holes 437L, 437R are formed respectively. In the circumferential surface of the frame 434L, 434R, a plurality of openings 438L, 438R is formed. Each of the frames 434L and 434R is joined to the case 433L, 433R of the oscillation generator 431L, 431R in the bottom circumference forming section. Each of the diaphragm 435L, 435R generates sound waves corresponding to the oscillations transmitted from the oscillation generator 431L, 431R. The diaphragms 435L and 435R are formed in substantially the same hollow truncated cone shape as that of the frame 434L, 434R using, for example, a magnesium thin plate, cone paper or the like of which surface is treated with anti-corrosion. These diaphragms 435L and 435R are fitted to the frames 434L and 434R respectively.

[0029] The respective speakers 430L and 430R are fitted to the speaker mounting members 420L, and 420R

from the upper face of the upper portion 210 via the speaker hole so that the oscillators 432L, 432R come to the top. By disposing each of the speakers 430L and 430R as described above, the surface inner than the circumference of the diaphragm 435L, 435R on the oscillator 432L, 432R is exposed to the outside of the main body 200. The speaker 430L and 430R is fixed to the main body 200 with set screws (not shown) inserted into the screw holes 437L, 437R. It is arranged so that, in a state that each of the speakers 430L and 430R is fixed to the main body 200, a space 450L, 450R is formed between the speakers 430L, 430R and the front end portions 423L, 423R of the speaker mounting members 420L, 420R. Also, in this state, a part of the circumference surface of the diaphragms 435L, 435R is exposed to the spaces 450L, 450R from the openings 438L, 438R formed on each of the frames 434L and 434R.

[0030] The tweeters 440L and 440R are small size speakers of, for example, 1.6 cm diameter for reproducing high tones. As shown in Fig. 1, the tweeter 440L is disposed at the left end of the upper portion 210; and the tweeter 440R is disposed at the right end of the upper portion 210. Each of the tweeters 440L and 440R is connected to the controller via a conductor (not shown) respectively. The tweeters 440L and 440R emit sounds corresponding to the signals input from the controller.

[0031] Generally, in the above-described embodiment, as the speakers for the acoustic device 400, the small size speakers 430L and 430R, which are of 10 cm in diameter covering full-range, are used. When signals are input from the controller to the voice coil of, for example, the oscillation generator 431L of the speaker 430L, the acoustic device 400 converts the input signals into oscillations with the voice coil and the magnetic body in the oscillation generator 431 L. The oscillation generator 431 L transmits the converted oscillations to the oscillator 432L. When the oscillations are transmitted from the oscillation generator 431 L, the oscillator 432L generates sound waves to the speaker hole at the surface inner than the circumference of the diaphragm 435L. Owing to this, the sounds are emitted from the speaker 430L to the outside of the instrument panel 100. Also, when the oscillations are transmitted from the oscillation generator 431 L, the oscillator 432L generates sound waves having inverted phase with respect to the sound waves, which are generated to the speaker hole, to the space 450L in the speaker mounting member 420L with the outer circumference surface of the diaphragm 435L exposed from the opening 438L in the frame 434L. The sound waves generated to the space 450L are transmitted via the resonant section 421 L, 414L to the reinforcement hole 211L with the inverted phase. That is, the oscillator 432L generates sound waves, which have the same phase as that of the sound waves generated to the speaker hole, to the reinforcement hole 211L with the outer circumference surface of the diaphragm 435L via the resonant sections 421L, 414L. Owing to this, the sounds are also emitted from the duct section 412L.

[0032] Thus, for example, the oscillator 432L generates the sound waves with the diaphragm 435L to the speaker hole. Also, the oscillator 432L generates the sound waves, which have the same phase as that of the sound waves generated to the speaker hole, with the diaphragm 435L to the reinforcement hole 211L via the hollow portion of the speaker mounting member 420L and the reinforcement 410; i.e., the resonant sections 421L, 414L. Owing to this, tube resonance is generated in the resonant sections 421L, 414L; and owing to the tube resonance, the sounds emitted from the duct section 412L can be made the sounds deeper than the sounds emitted to the outside from the speaker 430L on the instrument panel 100. Owing to this, even when the speakers 430L and 430R of small diameter, which hardly reproduce deep sounds, are employed, deep sounds can be reproduced; and thus, the cost and the weight of the speakers 430L and 430R can be reduced. Further, as a member, which enables the reproduction of deep sounds, mainly a conventional reinforcing member of the structural body is used. Accordingly, the number of component parts and the weight of the structural body are not increased. Further, since the speakers 430L and 430R are disposed in the instrument panel 100, it is not required to provide any waterproof cover for the speakers 430L and 430R to the automobile 1. Accordingly, the acoustic device 400, which is capable of reducing the cost and the weight as well as reproducing deep sounds, can be provided.

[0033] Also, the speaker mounting members 420L and 420R are joined to the reinforcement main body 411 of the reinforcement 410, and the respective speakers 430L and 430R are fitted with these speaker mounting members 420L and 420R. And in the substantially central area in the axial direction of the hollow portion of the reinforcement main body 411, the anti-interference member 413 for preventing the interference between sound waves passing through the resonant section 414L and the sound waves passing through the resonant section 414R is provided. Owing to this, the sound waves, which are generated to the resonant section 414L by the speaker 430L, is prevented from interfering with the sound waves, which are generated to the resonant section 414R by the speaker 430R. Owing to this arrangement, by inputting different signals to each of the speakers 430L and 430R with the controller, sounds, which are different from each other, can be emitted from the duct sections 412L and 412R. Accordingly, the acoustic device 400, which is capable of stereo-reproduction, can be provided.

[0034] In the front-end portion of the duct sections 412L and 412R, the reinforcement 410 is joined to the periphery edge of the reinforcement holes 211L and 211R from the lower face of the upper portion 210. Owing to this arrangement, for example, the resonant section 414L of the reinforcement main body 411 is communicated with the outside of the main body 200 via the

reinforcement hole 211 L. Owing to this, with the duct section 412L, the acoustic device 400 can emit deep sounds to the outside of the instrument panel 100; i.e., to the compartment of the automobile 1 via the reinforcement hole 211L. Accordingly, the driver and passengers can further enjoy the deep sounds.

[0035] For example, the speaker mounting member 420L comprises the front-end portion 423L formed in a cylindrical shape capable of being fitted with the speaker 430L, which is larger than the outer diameter of the reinforcement main body 411. Owing to this, when the speaker 430L is fixed to the main body 200, the space 450L is formed between the speaker 430L and the front-end portion 423L. Owing to this arrangement, by forming the space 450L between the speaker 430L and the front end portion 423L; compared to an arrangement, in which the space 450L is not formed, owing to the tube resonance, the level of the deep sounds, which is emitted from the duct section 412L, can be made larger. Accordingly, the acoustic device 400, which is capable of reproducing further vigorous deep sounds, can be provided.

[0036] In this embodiment, the structural body is taken to as the instrument panel 100 of the automobile 1. Owing to this arrangement, the conventional reinforcement 410, which has such function as the reinforcing member for the main body 200 of the instrument panel 100, can be used as the constituent member for the acoustic device 400 resulting in the above-described workings. Accordingly, the automobile 1 equipped with the acoustic device 400, which is capable of reproducing deep sounds without increasing the cost and the weight thereof can be provided.

[Modification of the embodiment]

[0037] The present invention is not limited to the above-described embodiment. Within the range where the object of the invention is achieved, the following modification is also included.

[0038] The example of the arrangement, in which the speaker mounting members 420L and 420R are joined to the reinforcement main body 411, the respective speakers 430L and 430R are fitted with these speaker mounting members 420L and 420R, and the anti-interference member 413 is provided in the substantially central area in the axial direction of the hollow portion of the reinforcement main body 411, has exemplified. The invention is not limit to the above, but the following arrangement may be adopted. That is, the following arrangement, in which, for example, in the substantially central area in the axial direction of the reinforcement main body 411, for example, only the speaker mounting member 420L is joined thereto, and only the speaker 430L is fitted to the speaker mounting member 420L, may be adopted. Owing to this arrangement, an acoustic device 400, which is capable of reproducing mono deep sounds without increasing the cost and the weight thereof, can be provided. Also, since the work to provide the anti-interference member 413 to the hollow portion of the reinforcement main body 411 is eliminated, the assembly work of the acoustic device 400 can be simplified resulted in a reduction of the manufacturing cost.

[0039] The configuration, in which, the reinforcement 410 is joined to the periphery edge of the reinforcement holes 211 L and 211 R from the lower face of the upper portion 210 at the front end portion of the duct sections 412L and 412R respectively, has been exemplified. The invention is not limited to the above. For example, the following arrangement may be adopted. That is, such arrangement, in which the reinforcement holes 211L and 211R are not formed, and the front-end portion of the duct sections 412L and 412R is located within the main body 200, may be adopted. Owing to this arrangement, a work to form the reinforcement holes 211 L and 211 R in the main body 200 and a work to join the duct sections 412L and 412R to the reinforcement holes 211L and 211R can be eliminated. Further, since the reinforcement 410 does not have to be bent, the work therefor is eliminated resulting in a reduction of the manufacturing cost.

[0040] For example, the configuration, in which, in the speaker mounting member 420L, the front end portion 423L formed in a cylindrical shape larger than the outer diameter of the reinforcement main body 411 so as to be fitted with the speaker 430L is provided, and the space 450L is formed between the speaker 430L and the front end portion 423L, has been exemplified. The invention is not limited to the above. For example, the following arrangement may be adopted. That is, an arrangement, in which the shape of the front-end portion 423L is formed in substantially the same truncated cone shape as that of the frame 434L of the speaker 430L, and the space 450L is not formed between the speaker 430L and the front-end portion 423L, may be adopted. Owing to this arrangement, the amount of the material used for forming the front-end portion 423L can be reduced. Accordingly, it is possible to reduce the cost and the weight of the acoustic device 400.

[0041] The configuration, in which the structural body is taken to as the instrument panel 100 of the automobile 1, has been exemplified. The invention is not limited to the above. It may be arranged so that, for example, a structural body may be taken to as a structural body of the instrument panel on an airplane or ship, or a rear dashboard of automobile or the like. Also, the invention may be applied to any structural body, in which a reinforcing member having a hollow portion is disposed therein.

[0042] The position and the shape of the speaker holes and the reinforcement holes 211 L and 211R formed in the main body 200 are not limited to the arrangement of the above-described embodiment, but may be appropriately changed. For example, at least any one of the speaker holes and the reinforcement holes 211 L and 211 R may be formed in a front portion

or lower portion (not shown) of the main body 200. Also, the position of the speaker holes and the reinforcement holes 211 L and 211 R may be exchanged with each other.

[Example of experiment]

[0043] Next, an example of experiment carried out to verify the effect of the embodiment will be described with reference to the relevant drawings. Fig. 4 is a block diagram showing the rough configuration of a measuring system used in the experiment. Fig. 5 is a perspective view showing the rough configuration of an acoustic device. Fig. 6 is a cross sectional view showing the rough configuration of the acoustic device. Fig. 7 is a graph illustrating an evaluation result of the experiment. In the following descriptions, the component members, which have the same function as those in the above-described embodiments, will be given with the same names and the explanations thereof will be omitted, or will be given just simply.

(Configuration of the measuring system)

[0044] First of all, the configuration of the measuring system will be described. In Fig. 4, reference numeral 500 denotes the measuring system. The measuring system 500 comprises a low-frequency oscillator 510, an amplifier 520, a voltmeter 530, an acoustic device 540, a microphone 550, an amplifier 560, a recorder 570, a power supply (not shown) and the like.

[0045] As shown in Fig. 4, the low-frequency oscillator 510 is connected, for example, to the power supply (not shown) and the amplifier 520 via the conductor (not shown). The low-frequency oscillator 510 comprises a frequency setting section, a frequency generator and the like (not shown). The low-frequency oscillator 510 is driven by a voltage supplied from the power supply (not shown), and outputs signals with the frequency, which is set by the frequency setting section, to the amplifier 520.

[0046] The amplifier 520 is connected to the speaker 430 in the acoustic device 540 via, for example, a conductor (not shown). The amplifier 520 amplifies the signals input from the low-frequency oscillator 510, and outputs the signals to the acoustic device 540.

[0047] The voltmeter 530 is connected via, for example, a conductor (not shown) in parallel to, for example, a conductor, which connects the amplifier 520 to the acoustic device 540. The voltmeter 530 measures the voltage input to the acoustic device 540.

[0048] The acoustic device 540 converts the signals input from the amplifier into sound waves, and outputs the sound waves therefrom. The acoustic device 540 comprises a baffle 541, which is equivalent to the reinforcement 410, a speaker-mounting member 542, a speaker 430 and the like.

[0049] As shown in Fig. 5, the baffle 541 is, for example, formed of a resin material and the like in a substantially cylindrical shape. In the following descriptions, the hollow portion of the baffle 541 will be referred to as resonant section 541A. The baffle 541 is formed in a substantially L-like shape with one end bent at substantially right angles. The baffle 541 comprises a baffle main body 541B with a substantially cylindrical shape and a duct section 541 C with a substantially cylindrical shape. As shown in Fig. 6, the other end of the baffle main body 541 B is closed.

[0050] The speaker-mounting member 542 is formed of, for example, a resin material and the like in a substantially cylindrical shape. In the following descriptions, the hollow portion of the speaker mounting member 542 will be referred as resonant section 542A. The speaker-mounting member 542 comprises a base end portion 542B, a front-end portion 542C and a joint section 542D. The speaker mounting member 542 is joined to the circumference surface of the baffle main body 541B with the base end portion 542B so that axial direction thereof is substantially parallel to the axial direction of the duct section 541 C. Owing to this arrangement, the resonant section 542A of the speaker-mounting member 542 is communicated with the outside of the baffle main body 541B via the resonant section 541A of the baffle main body 541 B.

[0051] The speaker 430 is fitted with the speaker-mounting member 542 so that the oscillator 432 comes to the top. In this state, a space 543 is formed between the speaker 430 and front-end portion 542C of the speaker-mounting member 542. The voice coil provided to the oscillation generator 431 of the speaker 430 is connected to the amplifier 520 via a conductor (not shown).

[0052] As shown in Fig. 4, the microphone 550 is located at a point 1m away from the front face of the speaker 430 of the acoustic device 540. Also, the microphone 550 is connected to the amplifier 560 via, for example, a cable (not shown). The microphone 550 receives the sound waves emitted from the duct section 541C and the speaker 430 of the acoustic device 540, and outputs the signals corresponding to the received sound waves to the amplifier 560.

[0053] The amplifier 560 is connected to the recorder 570 via, for example, a conductor (not shown). The amplifier 560 amplifies the signals input from the microphone 550 and outputs the signals to the recorder 570.

[0054] The recorder 570 records the signals input from the amplifier 560.

(Operation of the measuring system)

[0055] Next, the operation of the measuring system 500 will be described. First of all, the low-frequency oscillator 510 outputs signals of an arbitrary frequency, which is set by the frequency setting section, and of a voltage equivalent to 1W to the acoustic device 540 via the amplifier 520. Then, the acoustic device 540 emits

sound waves corresponding to the above signals through the duct section 541C and the speaker 430. The microphone 550 receives the sound waves emitted from the acoustic device 540, converts the received sound waves into signals, and outputs the signals to the recorder 570 via the amplifier 560. The recorder 570 records the signals input from the amplifier 560. Owing to this arrangement, the recorder 570 records the sound pressure of the sound waves of arbitrary frequency emitted from the acoustic device 540.

(Evaluation method of the acoustic device)

[0056] Next, evaluation method of the acoustic device 540 will be described. First of all, the measuring system 500 is set up in an anechoic room. In a state that the opening of the duct section 541C of the acoustic device 540 is closed, signals of arbitrary frequency and equivalent to 1W are output to the acoustic device 540 by the low-frequency oscillator 510. The microphone 550 receives the sound waves, which are emitted from the acoustic device 540, and the recorder 570 records the sound pressure thereof. After that, the frequency of the signals output from the low-frequency oscillator 510 is appropriately changed with the frequency setting section of the low-frequency oscillator 510, and the recorder 570 records the sound pressure of the sound waves emitted from the acoustic device 540. Then, in a state that the opening of the duct section 541 C of the acoustic device 540 is opened, the sound pressure of the sound waves emitted from the acoustic device is recorded by the recorder 570 in the above-described manner. In the following descriptions, the arrangement in which the opening of the duct section 541 C is closed will be referred to as arrangement of the comparative example; and the arrangement in which the opening of the duct section 541 C is opened will be referred to as arrangement of the present embodiment. And comparison of the curve characteristics in the arrangement of the comparative example and the arrangement of the present embodiment, which are recorded by the recorder 570 will be made.

(Evaluation result of the acoustic device)

[0057] Finally, the evaluation result of the acoustic device 540 will be described with reference to the related figure. Using the above-described evaluation method, the characteristic curves shown in Fig. 7 is obtained. In Fig. 7, the solid line represents the characteristic curve in the arrangement of the comparative example; the broken line represents the characteristic curve in the arrangement of the present embodiment. As shown in Fig. 7, in the arrangement of the present embodiment, with respect to the auditory sensation, in low frequency band of 150 Hz to 400 Hz where a large effect is obtained, an improvement effect of 4-5 dB has been obtained.

[Operation and effect of the embodiment]

[0058] In the above-described embodiments, to the acoustic device 400 provided on the instrument panel 100 with a built-in reinforcement 410 having the hollow portion, the speaker mounting members 420L and 420R, which have the hollow portions of which base ends are communicated with the reinforcement 410, and the speakers 430L and 430R, which are disposed in the opening at the front end side of the speaker mounting members 420L and 420R to emit sounds outside the instrument panel 100, are provided. And the hollow portions of the reinforcement 410 are used as the resonant sections 414L and 414R for allowing the sounds emitted by the speakers 430L and 430R to resonate. Further, the hollow portions of the speaker mounting members 420L and 420R are used as the resonant sections 421L and 421R for allowing the sounds emitted by the speakers 430L and 430R to resonate.

[0059] Owing to this arrangement, sounds are emitted to the outside of the instrument panel 100 from the speakers 430L and 430R. The sounds, which are emitted from the speakers 430L and 430R and pass through the resonant sections 421L, 414L, 421R and 414R, tube-resonate in the resonant section 42 1 L, 414L, 421 R and 414R. Owing to this, the sounds emitted from the duct sections 412L and 412R, can be changed to sounds deeper than the sounds, which are emitted to the outside of the instrument panel 100 from the speakers 430L and 430R. Owing to this, even when small size speakers 430L and 430R, which hardly reproduces deep sounds, are used, deep sounds can be reproduced; and thus, it is possible to reduce the cost and the weight of the speakers 430L and 430R. Also, as the member for enabling the reproduction of deep sounds, the reinforcement 410, which is a conventional reinforcing member of the instrument panel 100, is mainly used. Owing to this, the number of component parts and the weight of the instrument panel 100 are not increased. Further, since the speakers 430L and 430R are disposed in the instrument panel 100, it is not necessary to provide waterproof covers for the speakers 430L and 430R to the automobile 1. Accordingly, the acoustic device 400, which is capable of reducing the cost and the weight as well as reproducing deep sounds, can be provided.

Claims

1. An acoustic device, which is mounted on a structural body with a built-in reinforcing member having a hollow portion, comprising:

   a speaker for emitting sounds outside the structural body; and
   a speaker mounting member for disposing the speaker at the front end side thereof, and a

base end of which is communicated with the reinforcing member, wherein
the speaker mounting member includes a hollow portion communicated with a hollow portion of the reinforcing member, and the hollow portions are resonant sections for allowing the sounds emitted from the speaker to resonate.

2. The acoustic device according to claim 1, wherein
a plurality of the speakers and the speaker mounting members are disposed in pairs in parallel in the axial direction of the reinforcing member, and
an anti-interference member for preventing interference of sounds emitted by each of the speakers is provided in the hollow portion of the reinforcing member.

3. The acoustic device according to claims 1 or 2, wherein the resonant section is communicated with the outside of the structural body.

4. The acoustic device described in any one of claims 1 to 3, wherein a space is formed between the vicinity of the front-end side of the speaker mounting member and the speaker.

5. The acoustic device described in any one of claims 1 to 4, wherein the structural body is an instrument panel of a movable body, and the reinforcing member is a reinforcement.

FIG. 1

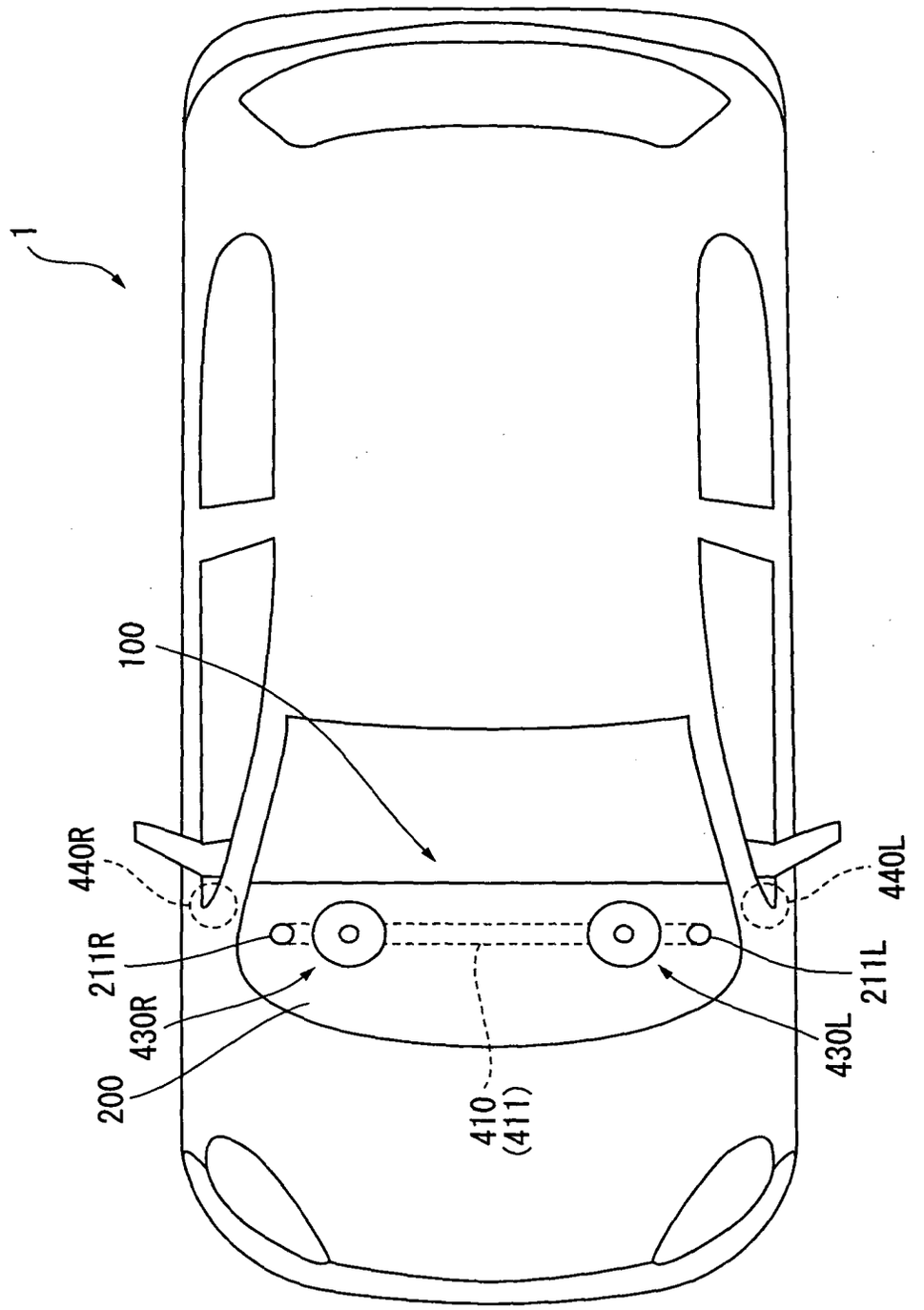


FIG. 2

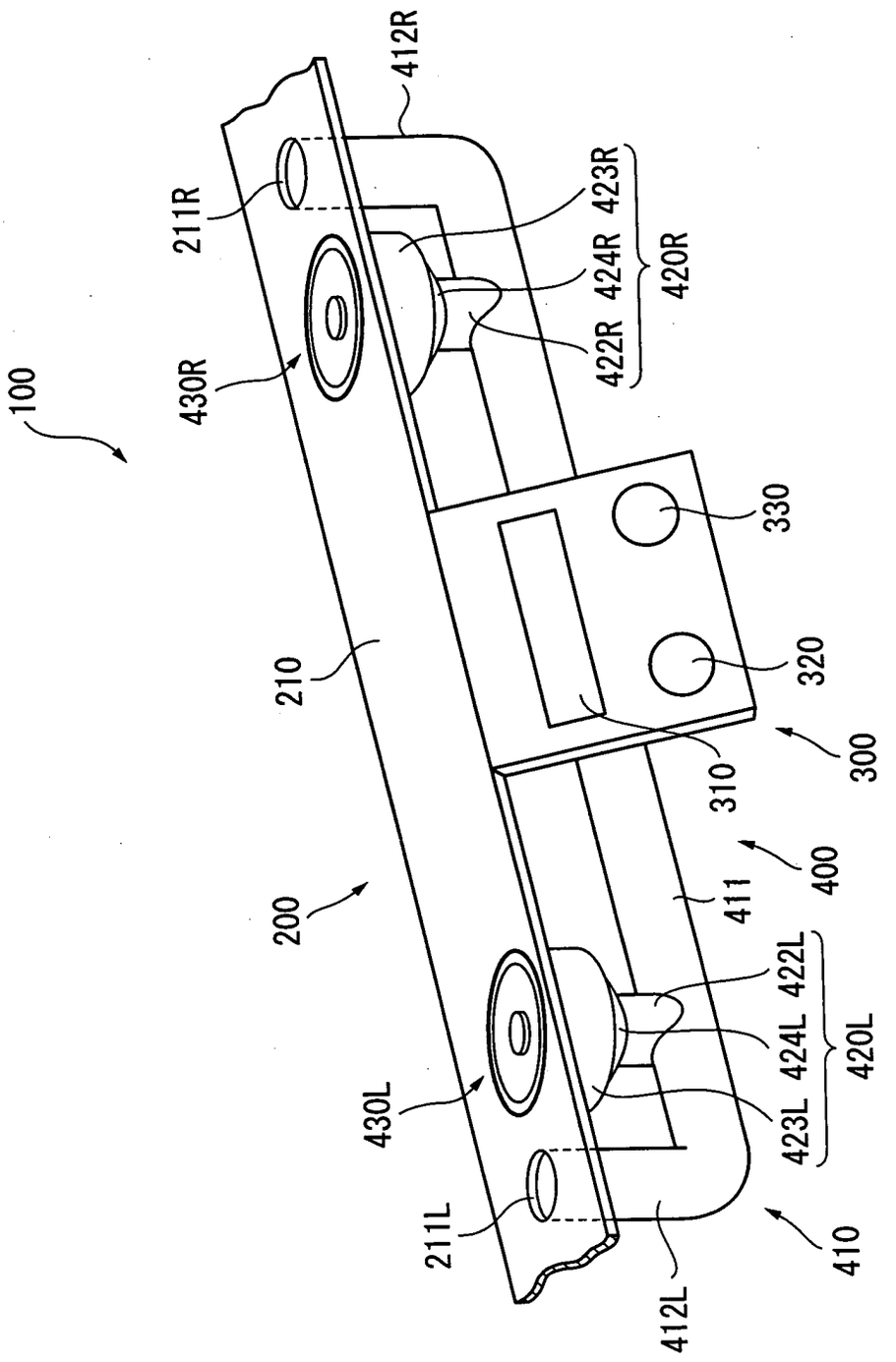

100
412R
211R
423R
424R
420R
422R
430R
330
320
210
310
300
200
411
400
422L
424L
420L
423L
430L
211L
412L
410

FIG. 3

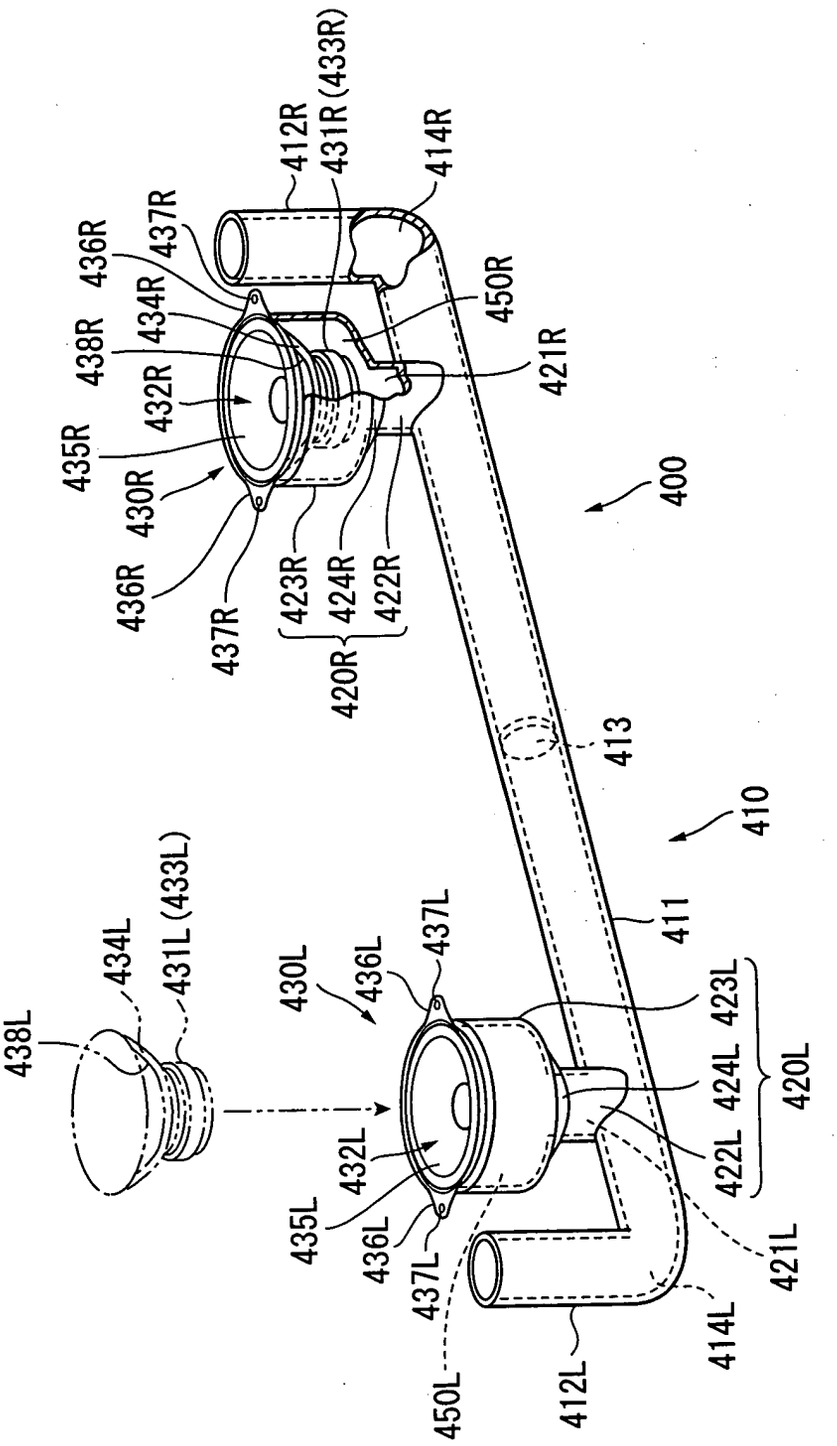

412R
431R (433R)
414R
436R
437R
434R
450R
438R
421R
432R
435R
430R
400
436R
437R
423R
424R
422R
420R
413
410
411
438L
434L
431L (433L)
430L
436L
437L
423L
424L
420L
432L
435L
436L
437L
422L
421L
414L
450L
412L

FIG. 4

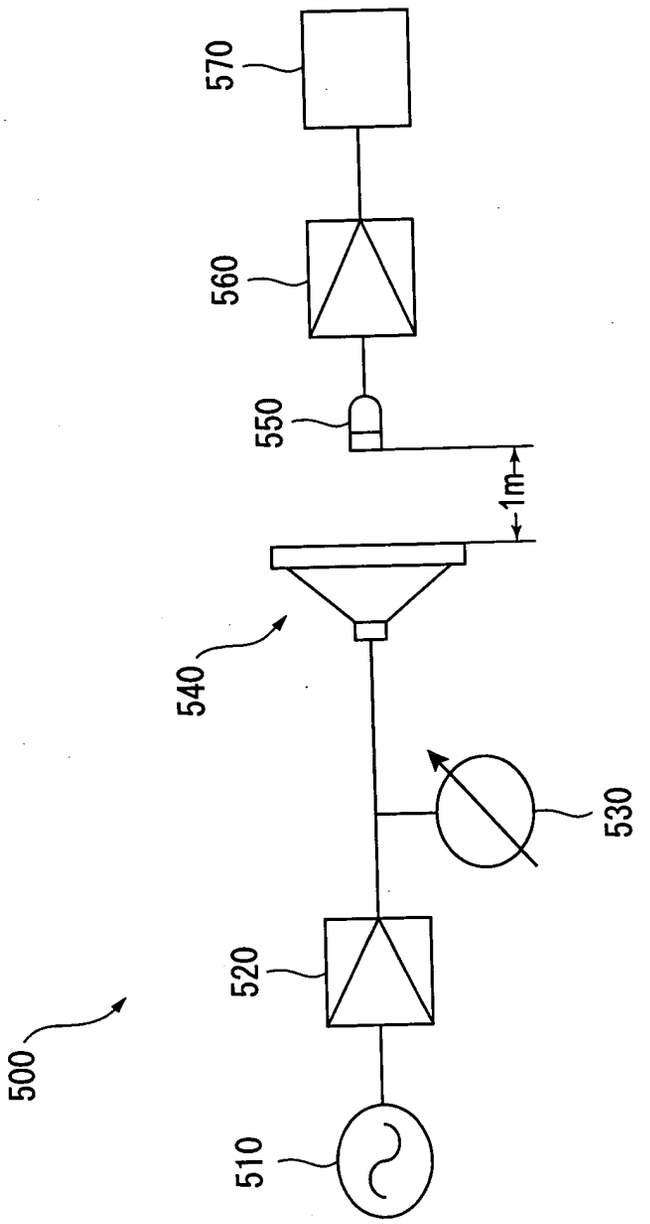


FIG. 5

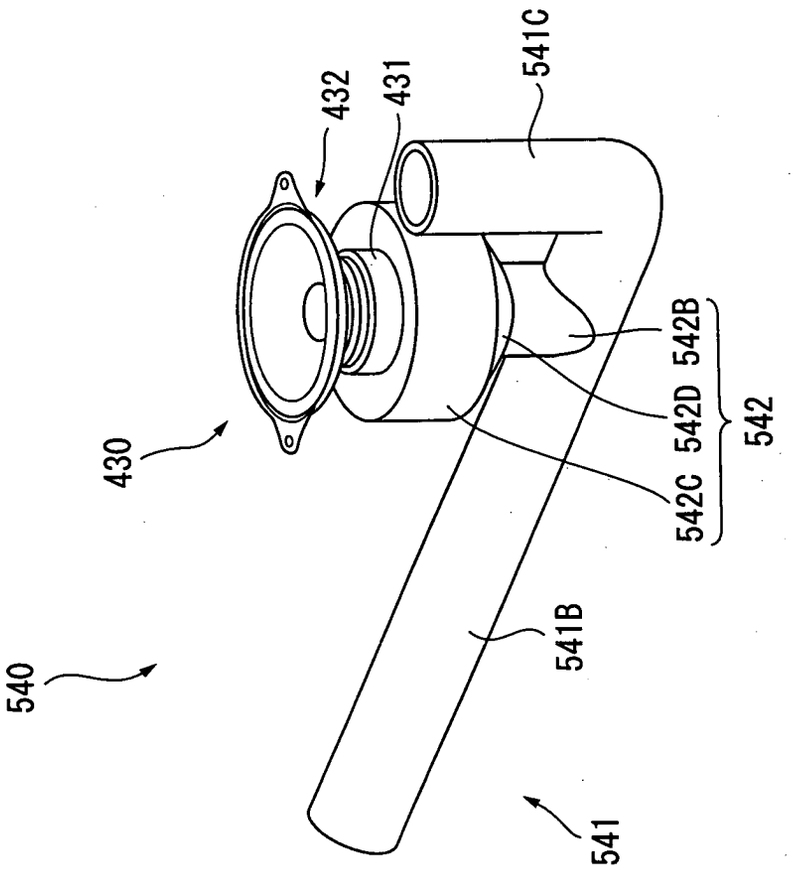


FIG. 6

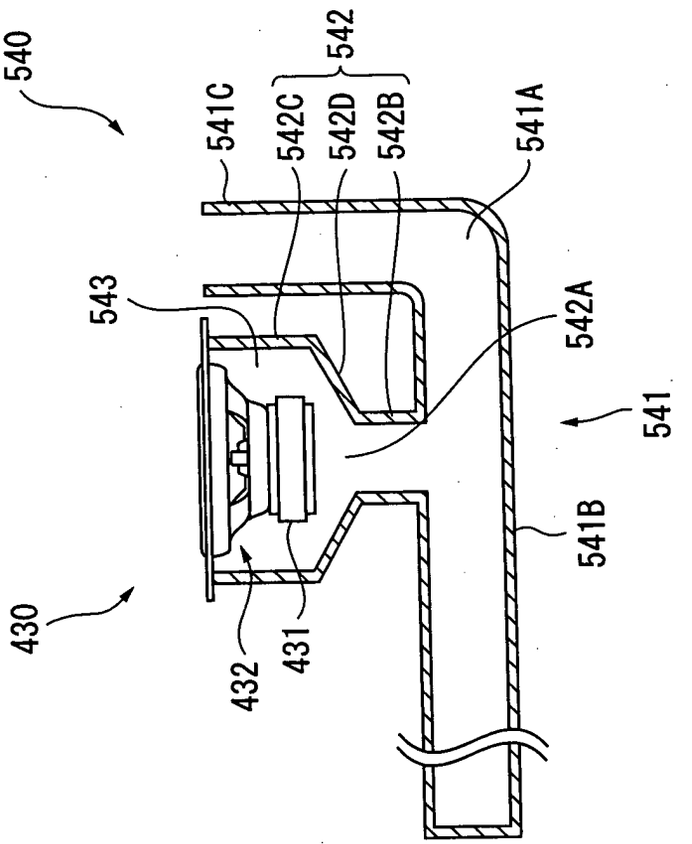
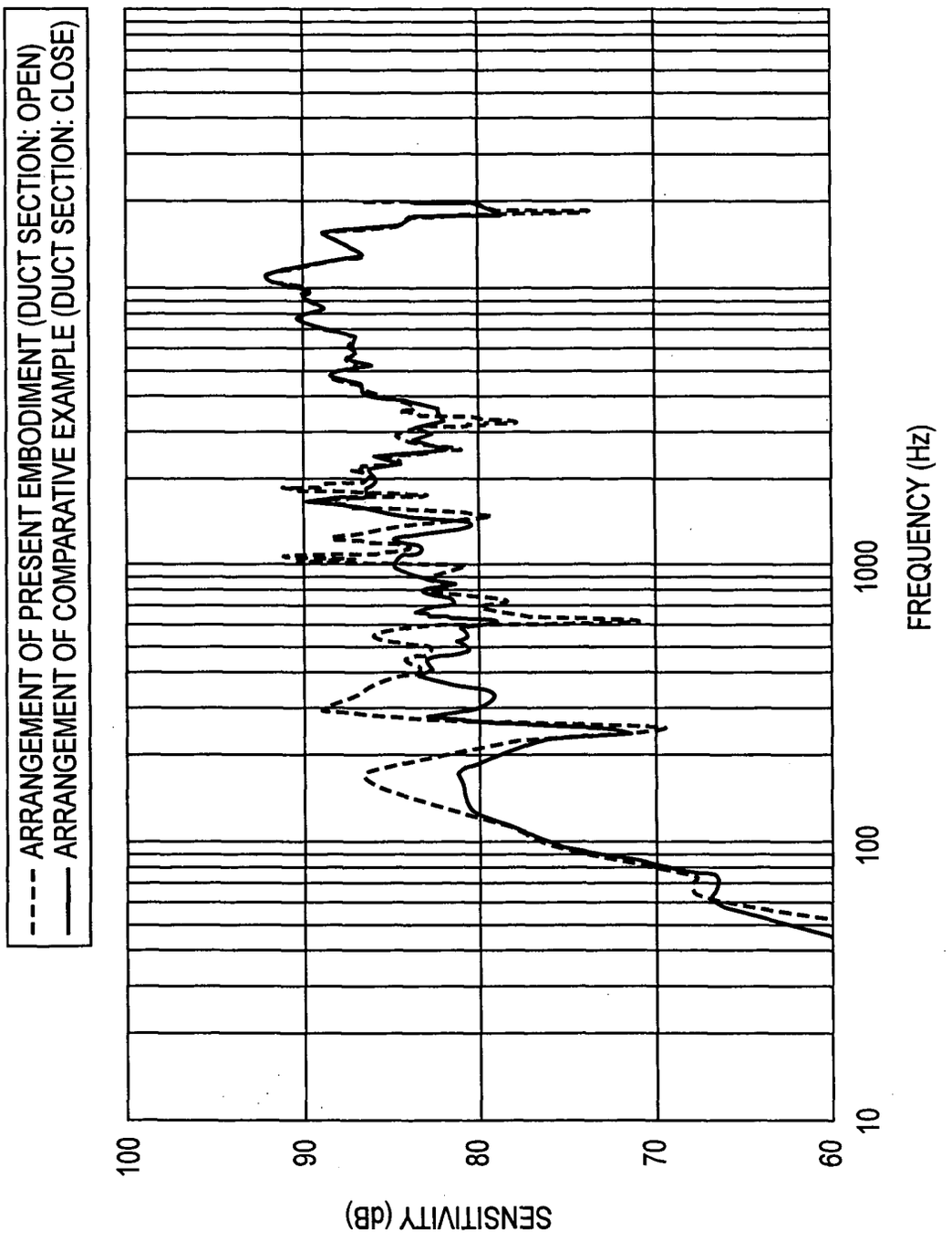


FIG. 7


---- ARRANGEMENT OF PRESENT EMBODIMENT (DUCT SECTION: OPEN)
—— ARRANGEMENT OF COMPARATIVE EXAMPLE (DUCT SECTION: CLOSE)
SENSITIVITY (dB)
100
90
80
70
60
10
100
1000
FREQUENCY (Hz)