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

(11) EP 3 503 585 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.06.2019 Bulletin 2019/26

(51) Int Cl.:
H04R 5/02 *(2006.01)* *H04R 9/06* *(2006.01)*

(21) Application number: **18214712.4**

(22) Date of filing: **20.12.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **21.12.2017 JP 2017244718**

(71) Applicant: **Alpine Electronics, Inc.**
Tokyo 145-8501 (JP)

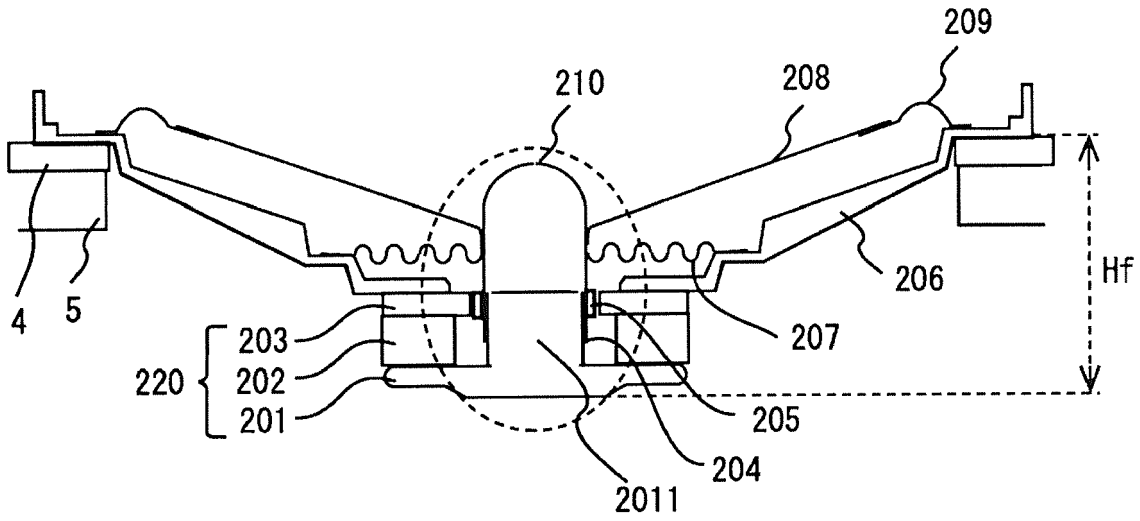
(72) Inventors:
- **KEI, Tanabe**
  Iwaki-city, Fukushima (JP)
- **MASAMI, Anzai**
  Iwaki-city, Fukushima (JP)

(74) Representative: **Schmitt-Nilson Schraud Waibel Wohlfrom**
Patentanwälte Partnerschaft mbB
Pelkovenstraße 143
80992 München (DE)

(54) VEHICLE SPEAKER SYSTEM AND AUDIO SYSTEM

(57) When an audio signal is applied from an audio device (1) to a voice coil (205), a voice coil bobbin (204) vibrates together with a connected diaphragm (208) due to an electromagnetic action of a magnetic flux generated from a magnetic circuit (220) and the audio signal flowing through the voice coil (205) according to the amplitude of the audio signal to generate a sound responsive to the audio signal. A front speaker (2) (Fig. 3A1) and a rear speaker (3) (Fig. 3B1) have substantially the same configuration, but the number of turns and the winding width (ChR) of the voice coil (205) of the rear speaker (3) (Fig. 3B2) is twice the number of turns and the winding width (ChF) of the voice coil (205) of the front speaker (2) (Fig. 3A2).

FIG. 3A1



EP 3 503 585 A1

Description

[0001] The present disclosure relates to vehicle speaker systems mounted to vehicles.

[0002] Known vehicle speaker systems mounted to automobiles include a vehicle speaker system including four speakers, that is, a left-channel front speaker 21 disposed on the left side in front of the front seat of an automobile, a right-channel front speaker disposed on the right side in front of the front seat of the automobile, a left-channel rear speaker disposed on the left side behind the front seat of the automobile, and a right-channel rear speaker disposed on the right side behind the front seat of the automobile.

[0003] For such vehicle speaker systems, there is a known technique for making up the lack of the playback volume of a bass range of the left-channel front speaker and the right-channel front speaker using the left-channel rear speaker and the right-channel rear speaker in such a manner that a left-channel audio signal output from the audio device is directly output to a left-channel front speaker 21 and is output to the left-channel rear speaker via a low-pass filter and that a right-channel audio signal output from the audio device is directly output to the right-channel front speaker and is output to the right-channel rear speaker via a low-pass filter (for example, JP2007-243430A).

[0004] Another known technique for such vehicle speaker systems is a technique of attaching a duct-shaped adaptor that gives an acoustic effect that increases the richness of the bass to the front of the speaker (for example, JP2005-311908A).

[0005] The above technique of outputting audio signals to the left-channel rear speaker and the right-channel rear speaker via a low-pass filter needs a cumbersome task for installing the low-pass filter in a relatively narrow speaker mounting space in the panel of the automobile.

[0006] Furthermore, the low-pass filter only cuts high tones, and the bass output characteristics of the left-channel rear speaker and the right-channel rear speaker themselves are not improved, so that the effect of enhancing the richness of the bass is limited.

[0007] With the technique of attaching the adaptor to the front of the speaker, the speaker to which the adaptor is attached cannot be mounted using a general speaker mounting structure provided on the panel of an automobile, so that the automobile needs a special panel structure.

[0008] Accordingly, it is an object to the present disclosure to improve the bass output characteristics of the rear speaker without the need for cumbersome tasks and a special structure of the automobile in a vehicle speaker system including a front speaker and a rear speaker.

[0009] The invention relates to a vehicle speaker system and audio system according to the appended claims. Embodiments are disclosed in the dependent claims. According to an aspect, the present disclosure provides a vehicle speaker system including front speakers to be respectively disposed on left and right panels of a vehicle cabin and rear speakers to be respectively disposed at positions behind the front speakers on the left and right panels. The front speakers and the rear speakers each include a diaphragm, a magnetic circuit configured to generate a magnetic flux, a voice coil bobbin connected to the diaphragm so as to be movable with respect to the magnetic circuit, and a voice coil wound around the outer circumference of the voice coil bobbin. The voice coil is disposed at a position where the magnetic flux generated by the magnetic circuit passes through. The voice coil receives an audio signal. The winding width of the voice coil of at least one of the rear speakers is larger than the winding width of the voice coil of at least one of the front speakers (in the following each designated as "the front speaker" and "the rear speaker", which may also cover more than one speakers, analogously.)

[0010] In the vehicle speaker system, thus setting the winding width of the voice coil of the rear speaker larger than the winding width of the front speaker prevents the distance between the voice coil and the magnetic circuit from increasing with the displacement of the voice coil bobbin at the output of bass to decrease a driving force for the diaphragm. This makes the sound pressure of the bass output from the rear speaker larger than that from the front speaker, with the sizes and other specifications of the front speaker and the rear speaker unchanged. Furthermore, this increases the weight of the vibration system that vibrates in response to an audio signal, such as the voice coil bobbin, the voice coil, and the diaphragm. This therefore increases the duration of the vibration of the vibration system at the output of bass to increase the lingering sound of the bass, enhancing the richness of the bass output from the rear speaker.

[0011] Since the front speaker and the rear speaker may have the same size, and there is no need for another component such as a low-pass filter, the rear speaker can be installed in a general speaker mounting structure provided on the panel of the automobile in the same procedure as for the front speaker.

[0012] In the vehicle speaker system, the voice coil of the rear speaker may have a larger number of turns than the voice coil of the front speaker.

[0013] In the vehicle speaker system, the wire of the voice coil of the rear speaker may have a larger diameter or a larger cross-sectional area than the voice coil of the front speaker.

[0014] This suppresses an increase in the electrical resistance of the voice coil of the rear speaker with an increase in the winding width of the voice coil, thereby suppressing a decrease in the sound pressure of the output sound due to an increase in the electrical resistance and increases the weight of the vibration system that vibrates in response to an audio signal, such as the voice coil bobbin, the voice coil, and the diaphragm, thereby enhancing the richness of the bass output from the rear speaker.

[0015] In the vehicle speaker system, the voice coil of

the front speaker may include a single coil, and the voice coil of the rear speaker may include a plurality of coils connected in parallel, and the coils may be wound in layers around the outer circumference of the voice coil bobbin.

[0016] This suppresses an increase in the electrical resistance of the voice coil of the rear speaker with an increase in the winding width of the voice coil, thereby suppressing a decrease in the sound pressure of the output sound due to an increase in the electrical resistance and increases the weight of the vibration system that vibrates in response to an audio signal, such as the voice coil bobbin, the voice coil, and the diaphragm, thereby enhancing the richness of the bass output from the rear speaker.

[0017] In the vehicle speaker system, the voice coil bobbin of the front speaker may be disposed so as to be movable in a front-to-back direction of the front speaker with respect to the magnetic circuit, and the voice coil bobbin of the rear speaker may be disposed so as to be movable in the front-to-back direction of the rear speaker with respect to the magnetic circuit. The diaphragm of the rear speaker may be smaller in size in the front-to-back direction than the diaphragm of the front speaker. The movable range of the voice coil bobbin of the rear speaker in the front-to-back direction may be larger than the movable range of the voice coil bobbin of the front speaker in the front-to-back direction.

[0018] This allows coping with an increase in the range (stroke) in which the voice coil bobbin vibrates with an increase in the driving force for the bass with almost no change in the overall size.

[0019] In the vehicle speaker system, the diaphragm of the rear speaker may be larger in weight and rigidity than the diaphragm of the front speaker.

[0020] This improves the sound quality of the bass output from the rear speaker and further increases the weight of the vibration system to further enhance the richness of the bass output from the rear speaker.

[0021] In the vehicle speaker system, the front speaker and the rear speaker may each include a frame that supports all of the diaphragm, the magnetic circuit, the voice coil bobbin, and the voice coil. The frame of each of the front speaker and the rear speaker may include a mounting portion to be fixed to the panel of the automobile. A size of the rear speaker from a rear surface of the mounting portion of the frame to a rear end of the rear speaker in the front-to-back direction is preferably within 120% of a size of the front speaker from a rear surface of the mounting portion of the frame to a rear end of the front speaker in the front-to-back direction.

[0022] The lateral size of the rear speaker is preferably within 120% of the lateral size of the front speaker.

[0023] Thus limiting the size of the rear speaker relative to the front speaker with a size that can be installed in the left and right panels of the automobile allows both of the front speaker and the rear speaker to be installed in the left and right panels of the automobile without hindrance, thereby providing flexibility in size setting for the rear speaker.

[0024] The present disclosure further provides an audio system including the vehicle speaker system and an audio device configured to output a front left-channel audio signal to at least one of the front speakers disposed on the left panel as an audio signal to be applied to the voice coil of the front speaker, output a front right-channel audio signal to at least one of the front speakers disposed on the right panel as an audio signal to be applied to the voice coil of the front speaker, output a rear left-channel audio signal to at least one of the rear speakers disposed on the left panel as an audio signal to be applied to the voice coil of the rear speaker, and output a rear right-channel audio signal to at least one of the rear speakers disposed on the right panel as an audio signal to be applied to the voice coil of the rear speaker. The front left-channel audio signal and the rear left-channel audio signal have the same frequency response, and the front right-channel audio signal and the rear right-channel audio signal have the same frequency response.

[0025] The audio system describe above achieves rich bass playback using only an audio device that outputs audio signals having the same frequency response to the front speaker and the rear speaker without using a special device, such as an amplifier for a subwoofer.

[0026] In a vehicle speaker system including a front speaker and a rear speaker, an embodiment of the present disclosure enhances the bass output characteristics of the rear speaker without the need for cumbersome tasks and a special structure of the automobile.

Fig. 1 is a block diagram illustrating the configuration of an audio system according to an embodiment of the present disclosure;

Fig. 2A is a diagram illustrating the placement of front speakers and rear speakers according to an embodiment of the present disclosure;

Fig. 2B is a diagram illustrating the placement of front speakers and rear speakers according to an embodiment of the present disclosure;

Fig. 3A1 is a cross-sectional view a front speaker according to an embodiment of the present disclosure illustrating the configuration thereof;

Fig. 3A2 is an enlarged view the front speaker according to an embodiment of the present disclosure;

Fig. 3B1 is a cross-sectional view a rear speaker according to an embodiment of the present disclosure illustrating the configuration thereof;

Fig. 3B2 is an enlarged view the rear speaker according to an embodiment of the present disclosure;

Fig. 4 is a graph illustrating an example of the frequency responses of the front speaker and the rear speaker according to an embodiment of the present disclosure;

Fig. 5A is a cross-sectional view a rear speaker according to another embodiment of the present disclosure illustrating the configuration thereof;

Fig. 5B is a cross-sectional view a rear speaker according to still another embodiment of the present disclosure illustrating the configuration thereof;
Fig. 6A is a cross-sectional view a rear speaker according to still another embodiment of the present disclosure illustrating the configuration thereof; and
Fig. 6B is a cross-sectional view a rear speaker according to still another embodiment of the present disclosure illustrating the configuration thereof.

[0027] Embodiments of the present disclosure will be described hereinbelow.

[0028] Fig. 1 illustrates the configuration of an audio system according to an embodiment of the present disclosure.

[0029] The audio system according to the present embodiment is a system installed in an automobile. The audio system is disposed inside the instrument panel of an automobile, such as a dashboard, and includes an audio device 1 that outputs two signals, an audio signal L of the left channel and an audio signal R of the right channel. The audio system further includes front speakers 2, that is, a left-channel front speaker 21 and a right-channel front speaker 22, and rear speakers 3, that is, a left-channel rear speaker 31 and a right-channel rear speaker 32.

[0030] The audio device 1 outputs the left-channel audio signals L to the left-channel front speaker 21 and the left-channel rear speaker 31 and outputs the left-channel audio signals R to the right-channel front speaker 22 and the right-channel rear speaker 32.

[0031] The left-channel audio signals L that the audio device 1 outputs to the left-channel front speaker 21 and the left-channel rear speaker 31 are audio signals having the same frequency response. The right-channel audio signals R that the audio device 1 outputs to the right-channel front speaker 22 and the right-channel rear speaker 32 are audio signals having the same frequency response.

[0032] In addition, the audio system may have one or two channels for outputting a monophonic signal. In this case, one channel may be split, and the two rear speakers may be connected to the channels, or the two rear speakers may be individually connected to the two channels.

[0033] Next, as illustrated in Figs. 2A and 2B, the left-channel front speaker 21 is disposed on the left side of the vehicle cabin in front of the seat back of the front seat, such as the inside of a left front door panel of the automobile. The right-channel front speaker 22 is disposed on the right side of the vehicle cabin in front of the seat back of the front seat, such as in the right front door panel of the automobile.

[0034] The left-channel rear speaker 31 is disposed on the left side of the vehicle cabin behind the seat back of the front seat of the automobile, such as in the left rear door panel of the automobile or in the panel behind the left rear door panel. The right-channel rear speaker 32 is disposed on the right side of the vehicle cabin behind the seat back of the front seat of the automobile, such as in the right rear door panel of the automobile or in the panel behind the right rear door panel. Since rear speakers having the same diameter as the diameter of the front speakers are to be installed in the rear door panel and so on, the diameters of the rear speaker mounting holes are set equal to the diameters of the mounting holes in the front door panel and so on.

[0035] Figs. 3A1, 3A2, 3B1, and 3B2 illustrate the configurations of the speakers 2 and 3.

[0036] Fig. 3A1 illustrates a cross-section of the front speaker 2 (the left-channel front speaker 21 and the right-channel front speaker 22). Fig. 3B1 illustrates a cross-section of the rear speaker 3 (the left-channel rear speaker 31 and the right-channel rear speaker 32).

[0037] As illustrated in Fig. 3A1, the front speaker 2 includes a yoke 201, a magnet 202, a top plate 203, a voice coil bobbin 204, a voice coil 205, a frame 206, a damper 207, a diaphragm 208, an edge 209, and a dust cap 210.

[0038] Assuming that the upper side in Fig. 3A1 is the front of the front speaker 2, and the lower side is the rear of the front speaker 2, the yoke 201 has a protrusion 2011 protruding to the front at the center. The magnet 202 in a ring shape is disposed around the outer circumference of the protrusion 2011. The top plate 203 in a ring shape made of iron or the like is disposed on the magnet 202. The yoke 201, the magnet 202, and the top plate 203 form a magnetic circuit 220.

[0039] The voice coil bobbin 204 has a hollow cylindrical shape. The voice coil 205 to which an audio signal is applied from the audio device 1 is wound around the outer circumference of the voice coil bobbin 204. The upper end of the voice coil bobbin 204 is sealed with the dust cap 210. The protrusion 2011 of the yoke 201 is inserted into the hollow of the voice coil bobbin 204 and guides the forward-reverse movement of the voice coil bobbin 204. The voice coil 205 is disposed at the position between the protrusion 2011 of the yoke 201 and the top plate 203, through which a magnetic flux generated between the inner peripheral ends of the top plate 203 by the magnetic circuit 220 passes.

[0040] The frame 206 has flanges at the inner circumferential end and the outer circumferential end of the cone shape. The flange at the inner circumferential end is fixed to the upper surface of the top plate 203. The flange at the outer circumferential end of the frame 206 is fixed to a rim 5 of a speaker mounting opening provided in the panel of the automobile, with a ring-shaped baffle board 4 in between, in such a manner that almost all of a portion of the front speaker 2 lower than the flange at the outer circumferential end of the frame 206 is fit in the panel.

[0041] The damper 207 has a ring shape, whose inner circumferential end is fixed to the voice coil bobbin 204, and whose outer circumferential end is fixed to the frame 206.

[0042] The diaphragm 208 has a cone-shape, whose outer circumferential end is fixed to the front end of the

frame 206 at the edge 209. The inner circumferential end of the diaphragm 208 is fixed to the front end of the voice coil bobbin 204.

[0043] In such a configuration of the speaker 2, when an audio signal is applied from the audio device 1 to the voice coil 205, the voice coil bobbin 204 is vibrated forward and backward by the electromagnetic action of a magnetic flux generated from the magnetic circuit 220 and the audio signal flowing through the voice coil 205 according the amplitude of the audio signal. When the voice coil bobbin 204 vibrates, the diaphragm 208 connected to the voice coil bobbin 204 vibrates to generate a sound responsive to the audio signal.

[0044] As illustrated in Fig. 3B1, the rear speaker 3 has a configuration similar to the configuration of the front speaker 2 illustrated in Fig. 3A1, but differs in the number of turns and the winding width of the voice coil 205.

[0045] As illustrated in Fig. 3A2 in which the periphery of the voice coil 205 of the front speaker 2 is illustrated in enlarged view, and as illustrated in Fig. 3B2 in which the periphery of the voice coil 205 of the rear speaker 3 is illustrated in enlarged view, the number of turns of the voice coil 205 of the rear speaker 3 is twice the number of turns of the voice coil 205 of the front speaker 2, and the winding width ChR of the voice coil 205 of the rear speaker 3 is twice the winding width ChF of the voice coil 205 of the front speaker 2.

[0046] Fig. 3A2 and Fig. 3B2 schematically show the difference in the voice coil 205 between the front speaker 2 and the rear speaker 3. The actual number of turns and the actual wire-diameter of each voice coils 205 differ from those in the diagrams.

[0047] Thus setting the number of turns and the winding width of the voice coil 205 of the rear speaker 3 twice those of the front speaker 2 prevents the distance between the voice coil 205 and the top plate 203 from increasing with the displacement of the voice coil bobbin 204 at the output of bass having a long vibration period to decrease a driving force for the diaphragm 208. This allows increasing the driving force for a bass range, thereby making the sound pressure in the bass output from the rear speaker 3 larger than that from the front speaker 2, with the sizes and other specifications of the front speaker 2 and the rear speaker 3 unchanged. Furthermore, this increases the weight of the vibration system that vibrates in response to an audio signal, such as the voice coil bobbin 204, the voice coil 205, and the diaphragm 208. This therefore increases the duration of the vibration of the vibration system at the output of bass to increase the lingering sound of the bass, enhancing the richness of the bass output from the rear speaker 3.

[0048] Since the front speaker 2 and the rear speaker 3 may have the same size, and there is no need for another component such as a low-pass filter, the rear speaker 3 can be installed in a general speaker mounting structure provided on the panel of the automobile in the same procedure as for the front speaker 2.

[0049] Fig. 4 illustrates an example of the frequency responses of bass of the front speaker 2 and the rear speaker 3 when the number of turns and the winding width of the voice coil 205 of the rear speaker 3 are set twice those of the front speaker 2.

[0050] As illustrated, the output sound pressure in the bass range of 80 Hz or less of the rear speaker 3 is larger than the output sound pressure in the bass range of the front speaker 2. This shows that the present embodiment can enhance the output characteristic of the bass range of the rear speaker 3.

[0051] Since sounds below 80 Hz sound omnidirectional for human ears without sense of direction, enhancing the output characteristics of the bass range of only the rear speaker 3 allows sounds in the bass range with a higher sound pressure to be output to the users in the front seats almost without disturbing the localization of the sound image due to the sound output from the front speaker 2.

[0052] An embodiment of the present disclosure has been described above.

[0053] In the above embodiment, the front speaker 2 and the rear speaker 3 are the same except the number of turns and the winding width of the voice coil 205. Alternatively, the front speaker 2 and the rear speaker 3 may differ in another element other than the number of turns and the winding width of the voice coil 205.

[0054] However, the length Hr from the rear end of the rear speaker 3 to the rear surface of the flange at the outer circumferential end of the frame 206 illustrated in Fig. 3B1 is set within 120% of the length Hf from the rear end of the front speaker 2 to the rear surface of the flange at the outer circumferential end of the frame 206 illustrated in Fig. 3A1 so that both of the front speaker 2 and the rear speaker 3 can fit in the panel of the automobile without hindrance.

[0055] The lateral (radial) dimension of the rear speaker 3 is the same as the lateral (radial) dimension of the front speaker 2. This allows the rear speaker 3 to be installed without hindrance even if the diameter of the rear speaker mounting hole formed in the rear door panel is the same as the diameter of the mounting hole formed in the front door panel or the like.

[0056] In the above embodiment, the number of turns and the winding width of the voice coil 205 of the rear speaker 3 is twice the number of turns and the winding width of the front speaker 2. However, the number of turns and the winding width of the voice coil 205 of the rear speaker 3 may not necessarily be twice those of the front speaker 2. It is only required that the winding width of the voice coil 205 of the rear speaker 3 is larger than that of the front speaker 2 to enhance the output characteristics of the bass from the rear speaker 3.

[0057] In the above embodiment, the winding width of the voice coil 205 of the rear speaker 3 is set larger than that of the front speaker 2 by setting the number of turns of the voice coil 205 of the rear speaker 3 larger than that of the front speaker 2. Alternatively, the winding width of the voice coil 205 of the rear speaker 3 may be set larger

than that of the front speaker 2 by setting the diameter or the cross-sectional area of the voice coil 205 of the rear speaker 3 larger than that of the front speaker 2.

[0058] In other words, for example, the winding width or the cross-sectional area of the voice coil 205 of the rear speaker 3 may be set twice the winding width of the front speaker 2 by setting the diameter or the cross-sectional area of the voice coil 205 of the rear speaker 3 twice that of the front speaker 2, as illustrated in Fig. 5A.

[0059] This suppresses an increase in the electrical resistance of the voice coil 205 of the rear speaker 3 with an increase in the winding width of the voice coil 205, thereby suppressing a decrease in the sound pressure of the output sound due to an increase in the electrical resistance and increases the weight of the vibration system, thereby enhancing the richness of the bass output from the rear speaker 3.

[0060] The voice coil 205 of the rear speaker 3 in the above embodiment may be such that two voice coils whose winding width is larger than that of the front speaker 2 are connected in parallel, and the two voice coils are layered around the outer circumference of the voice coil bobbin 204.

[0061] In other words, for example, two coils 2051 and 2052 whose number of turns and winding width are twice those of the voice coil 205 of the front speaker 2 may used as the voice coil 205 of the rear speaker 3 and may be layered around the other circumference of the voice coil bobbin 204, as illustrated in Fig. 5B. In this case, the two coils 2051 and 2052 are connected in parallel, so that the audio signal from the audio device 1 is applied in parallel to the coils 2051 and 2052.

[0062] This also suppresses an increase in the electrical resistance of the voice coil 205 of the rear speaker 3 with an increase in the winding width of the voice coil 205, thereby suppressing a decrease in the sound pressure of the output sound due to an increase in the electrical resistance and increases the weight of the vibration system, thereby enhancing the richness of the bass output from the rear speaker 3.

[0063] As illustrated in Fig. 6A, the rear speaker 3 according to the above embodiment may be configured such that the length Fh of the frame 206 and the diaphragm 208 in the front-to-back direction may be smaller than that of the front speaker 2, and the distance Yh from the rear end of the voice coil bobbin 204 to the surface of the yoke 201 behind the rear end may be increased by a corresponding amount.

[0064] This allows coping with an increase in the range (stroke) in which the voice coil bobbin 204 vibrates with an increase in the driving force for the bass without almost no change in overall size.

[0065] As illustrated in Fig. 6B, the rear speaker 3 of the above embodiment may use a diaphragm 208 having a larger weight and rigidity than the diaphragm 208 of the front speaker 2.

[0066] This improves the sound quality of the bass output from the rear speaker 3 and further increases the weight of the vibration system to further enhance the richness of the bass output from the rear speaker 3.

Claims

1. A vehicle speaker system comprising:

front speakers (2, 21, 22) configured to be respectively disposed on left and right panels of a vehicle cabin; and
rear speakers (3, 31, 32) configured to be respectively disposed at positions behind the front speakers (2) on the left and right panels,
wherein the front speakers (2) and the rear speakers (3) each include a diaphragm (208), a magnetic circuit (220) configured to generate a magnetic flux, a voice coil bobbin (204) connected to the diaphragm (208) so as to be movable with respect to the magnetic circuit (220), and a voice coil (205) wound around the outer circumference of the voice coil bobbin (204), the voice coil (205) being disposed at a position where the magnetic flux generated by the magnetic circuit (220) passes through, the voice coil (205) configured to receive an audio signal, and
wherein the vehicle speaker system is **characterized in that** a winding width (ChR) of the voice coil (205) of at least one of the rear speakers (3) is larger than a winding width (ChF) of the voice coil (205) of at least one of the front speakers (2).

2. The vehicle speaker system according to Claim 1,
wherein the voice coil (205) of the at least one of the rear speakers (3) has a larger number of turns than the voice coil (205) of the at least one of the front speakers (2) .

3. The vehicle speaker system according to Claim 1 or 2,
wherein the wire of the voice coil (205) of the at least one of the rear speakers (3) has a larger diameter or a larger cross-sectional area than the voice coil (205) of the at least one of the front speakers (2).

4. The vehicle speaker system according to one of Claims 1 to 3,
wherein the voice coil of the at least one of the front speakers (2) is composed of a single coil, and
wherein the voice coil (205) of the at least one of the rear speakers (3) is composed of a plurality of coils connected in parallel.

5. The vehicle speaker system according to any one of Claims 1 to 4,
wherein the voice coil bobbin (204) of the at least one of the front speakers (2) is disposed so as to be

movable in a front-to-back direction of the front speaker (2) with respect to the magnetic circuit (220), wherein the voice coil bobbin (204) of the at least one of the rear speakers (3) is disposed so as to be movable in the front-to-back direction of the rear speaker (3) with respect to the magnetic circuit (220), wherein the diaphragm (208) of the at least one of the rear speakers (3) is smaller in size in the front-to-back direction than the diaphragm (208) of the at least one of the front speakers (2), and
wherein a movable range of the voice coil bobbin (204) of the at least one of the rear speakers (3) in the front-to-back direction is larger than a movable range of the voice coil bobbin (204) of the at least one of the front speakers (2) in the front-to-back direction.

6. The vehicle speaker system according to any one of Claims 1 to 5,
wherein the diaphragm (208) of the at least one of the rear speakers (3) is larger in weight and rigidity than the diaphragm (208) of the at least one of the front speakers (2) .

7. The vehicle speaker system according to any one of Claims 1 to 6,
wherein the at least one of the front speakers (2) and the at least one of the rear speakers (3) each include a frame (206) that supports all of the diaphragm (208), the magnetic circuit (220), the voice coil bobbin (204), and the voice coil (205),
wherein the frame (206) of each of the at least one of the front speakers (2) and the at least one of the rear speakers (3) includes a mounting portion to be fixed to the panel of the automobile, and
wherein a size (Hr) of the at least one of the rear speakers (3) from a rear surface of the mounting portion of the frame (206) to a rear end of the rear speaker (3) in the front-to-back direction is within 120% of a size (Hf) of the at least one of the front speakers (2) from a rear surface of the mounting portion of the frame (206) to a rear end of the front speaker (2) in the front-to-back direction.

8. The vehicle speaker system according to any one of Claims 1 to 7,
wherein a lateral size of the at least one of the rear speakers (3) is within 120% of a lateral size of the at least one of the front speakers (2).

9. An audio system comprising:

the vehicle speaker system according to any one of Claims 1 to 8; and
an audio device configured to output a front left-channel audio signal to at least one of the front speakers (21) disposed on the left panel as an audio signal to be applied to the voice coil (205) of the front speaker (21), output a front right-channel audio signal to at least one of the front speakers (22) disposed on the right panel as an audio signal to be applied to the voice coil (205) of the front speaker (22), output a rear left-channel audio signal to at least one of the rear speakers (31) disposed on the left panel as an audio signal to be applied to the voice coil (205) of the rear speaker (31), and output a rear right-channel audio signal to at least one of the rear speakers (32) disposed on the right panel as an audio signal to be applied to the voice coil (205) of the rear speaker (32), and
wherein the front left-channel audio signal and the rear left-channel audio signal have a same frequency response, and the front right-channel audio signal and the rear right-channel audio signal have a same frequency response.

FIG. 1

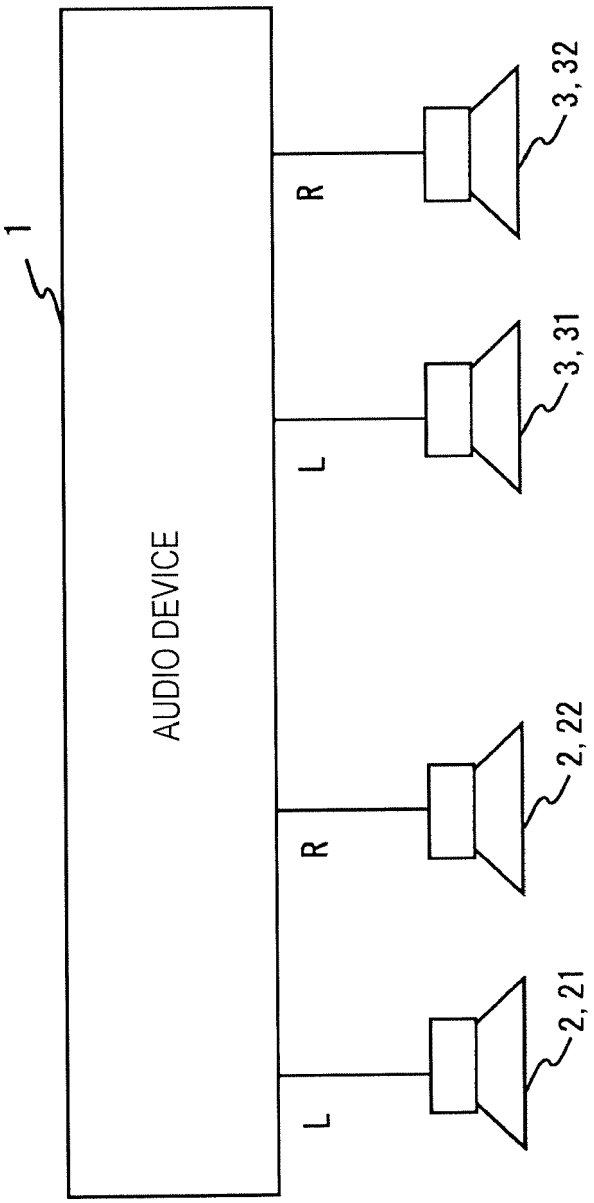


FIG. 2A

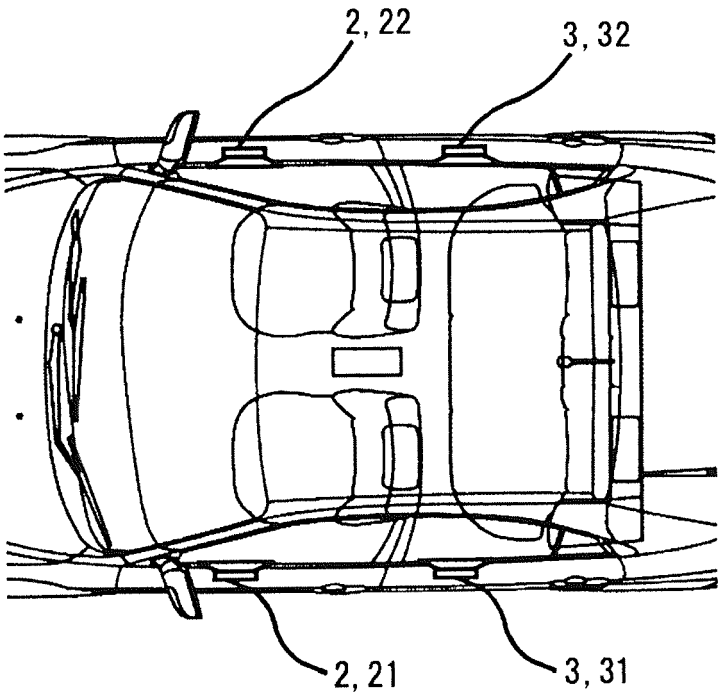


FIG. 2B

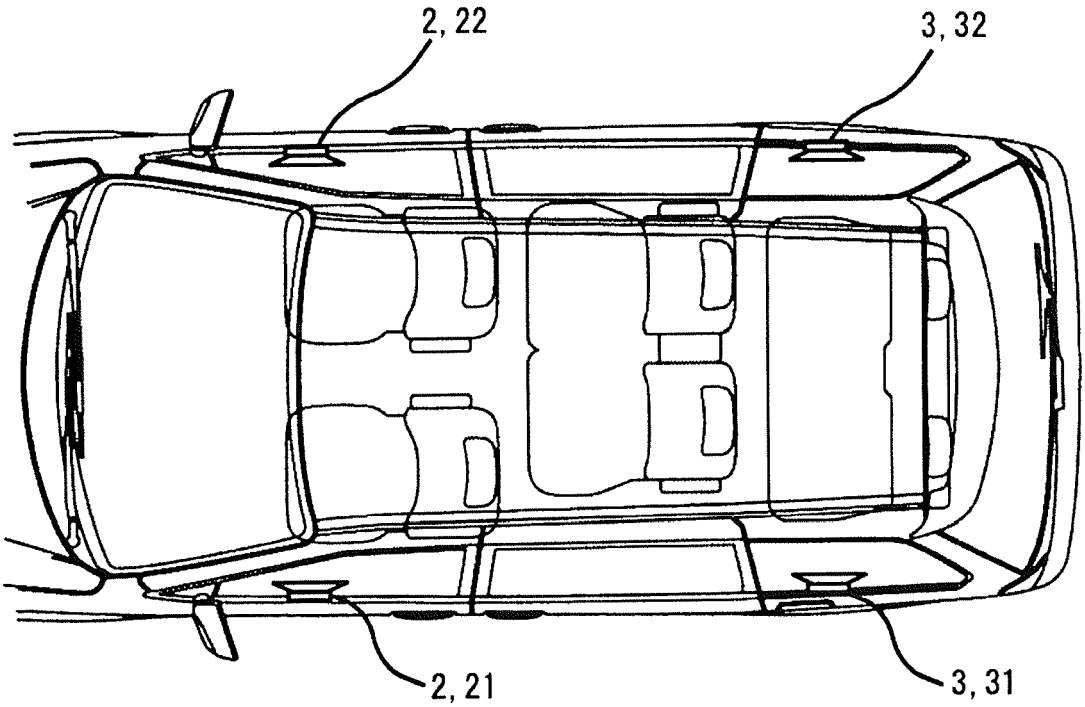


FIG. 3A1

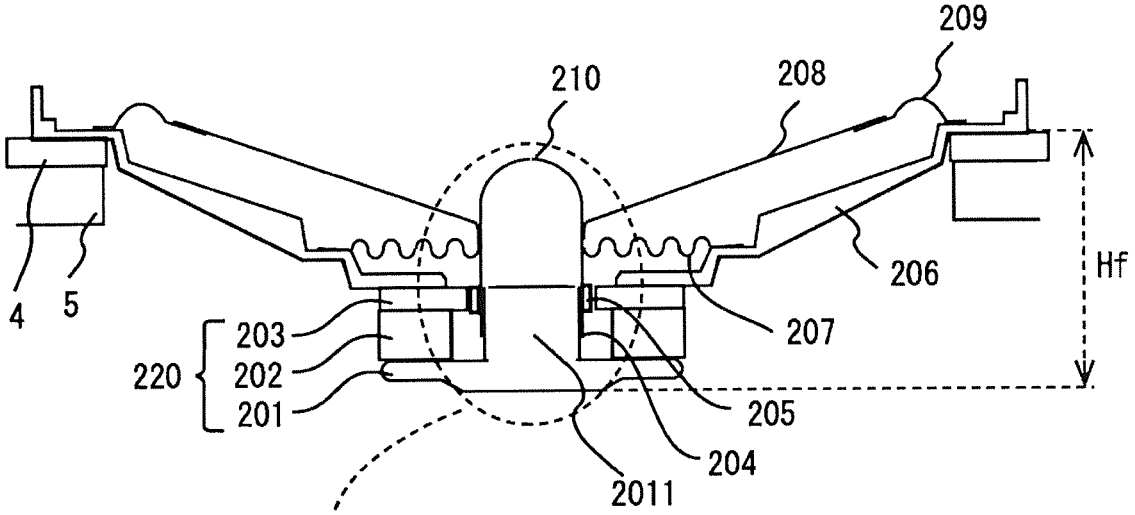


FIG. 3A2

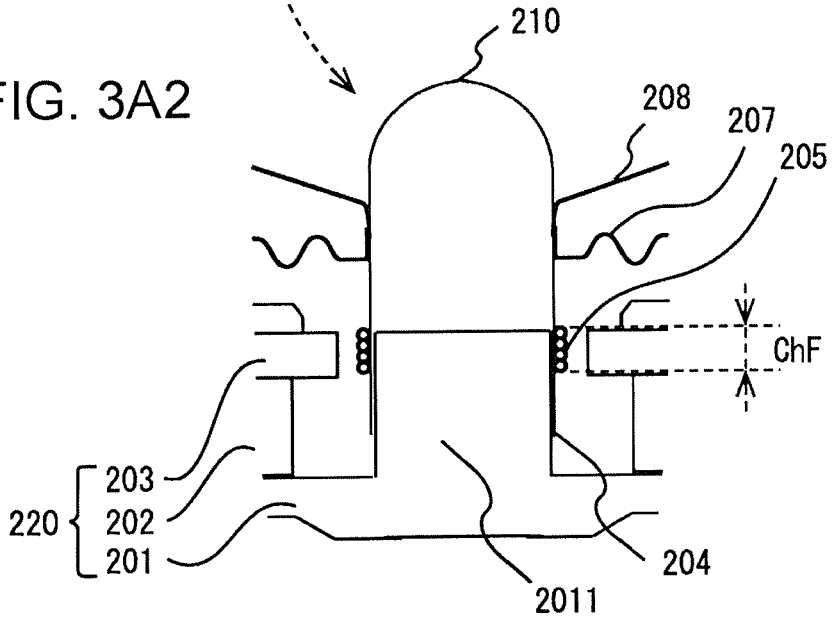


FIG. 3B1

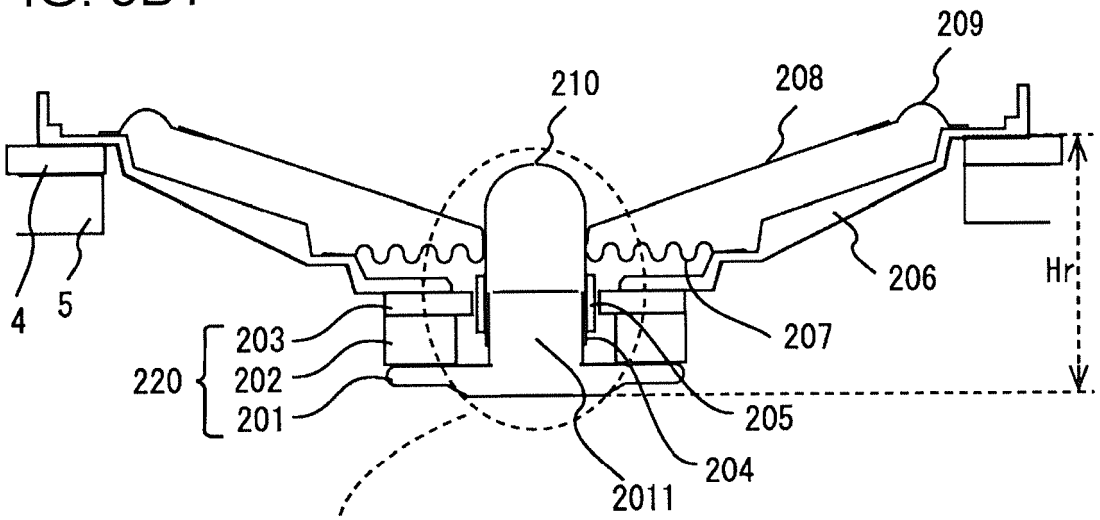


FIG. 3B2

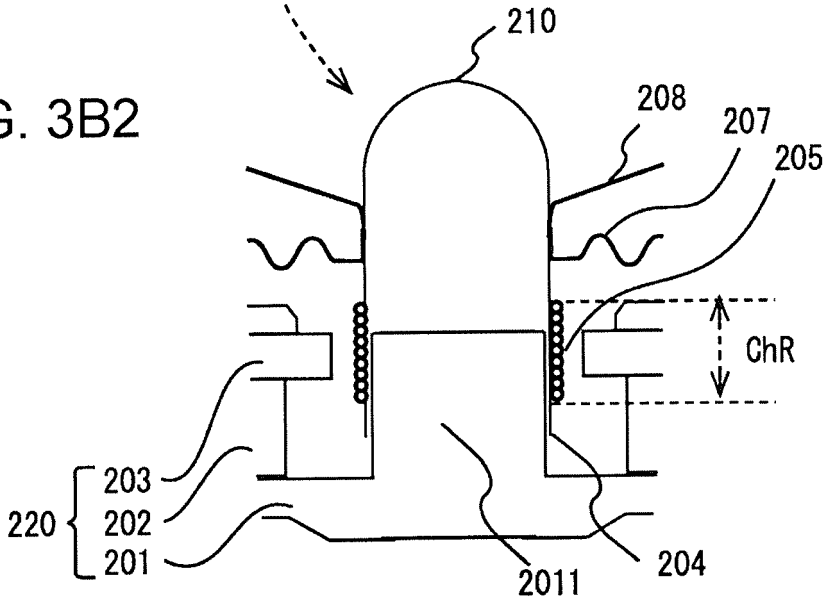


FIG. 4

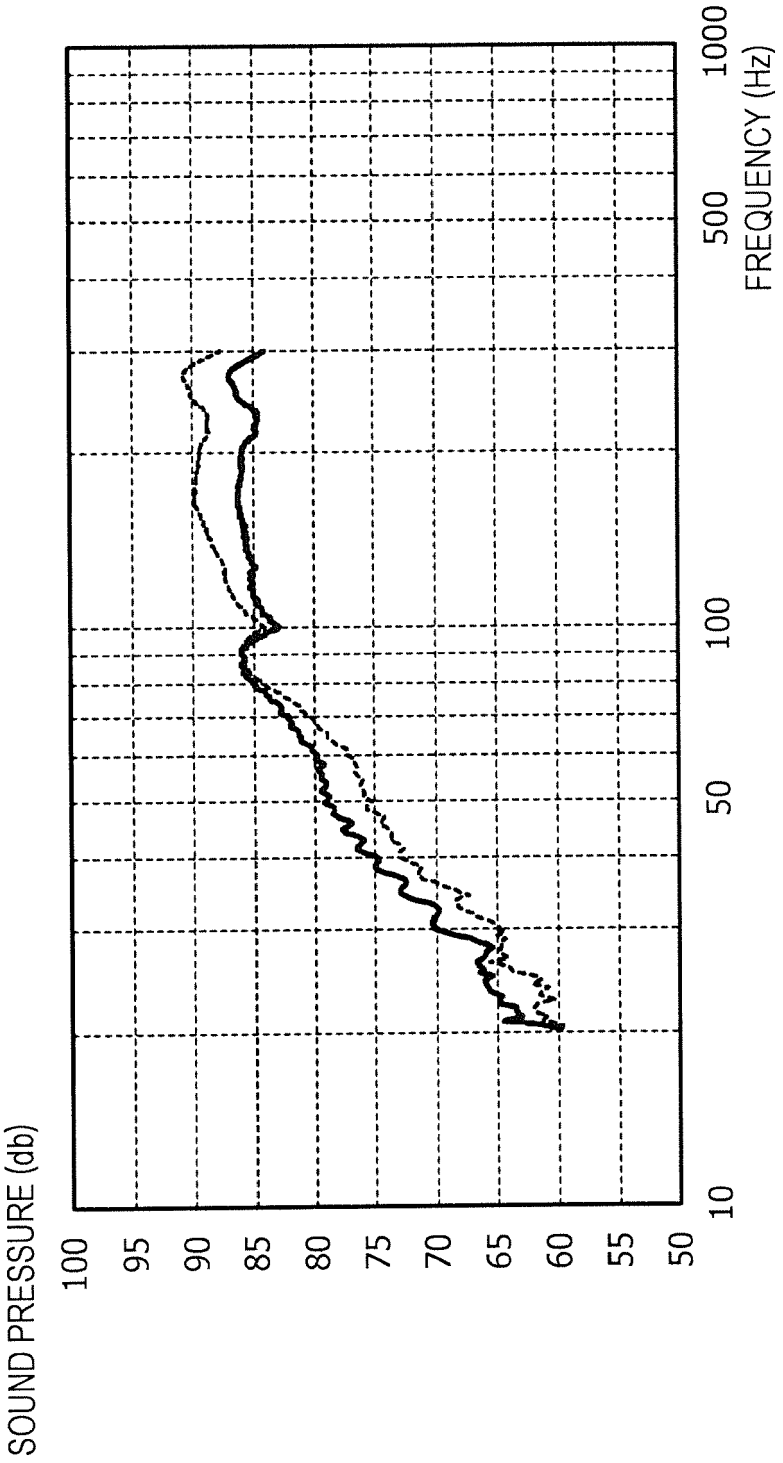

SOUND PRESSURE (db)
100
95
90
85
80
75
70
65
60
55
50
10
50
100
500
1000
FREQUENCY (Hz)

FIG. 5A

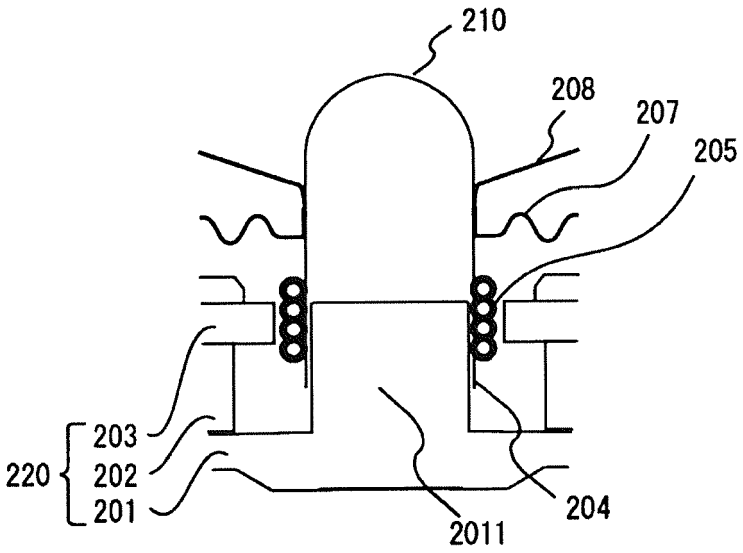

210
208
207
205
203
220
202
201
204
2011

FIG. 5B

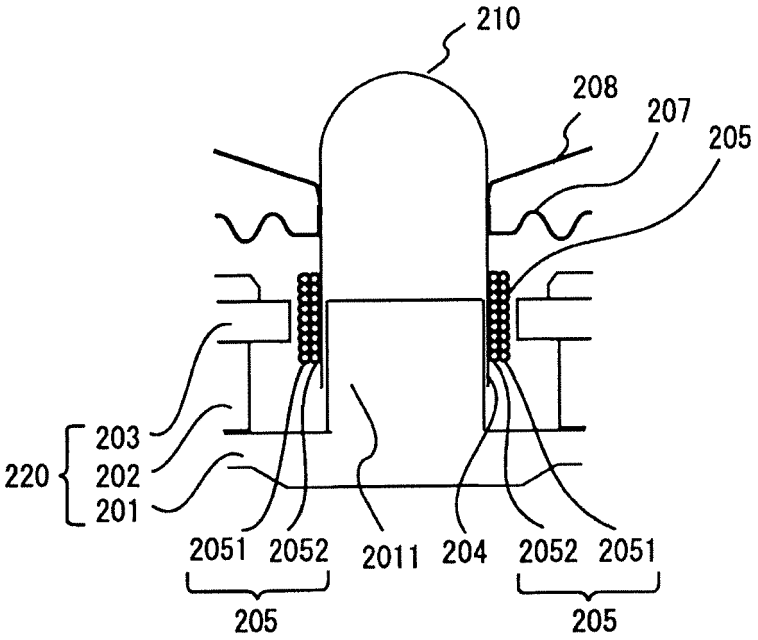

210
208
207
205
203
220
202
201
2051
2052
2011
204
2052
2051
205
205

FIG. 6A

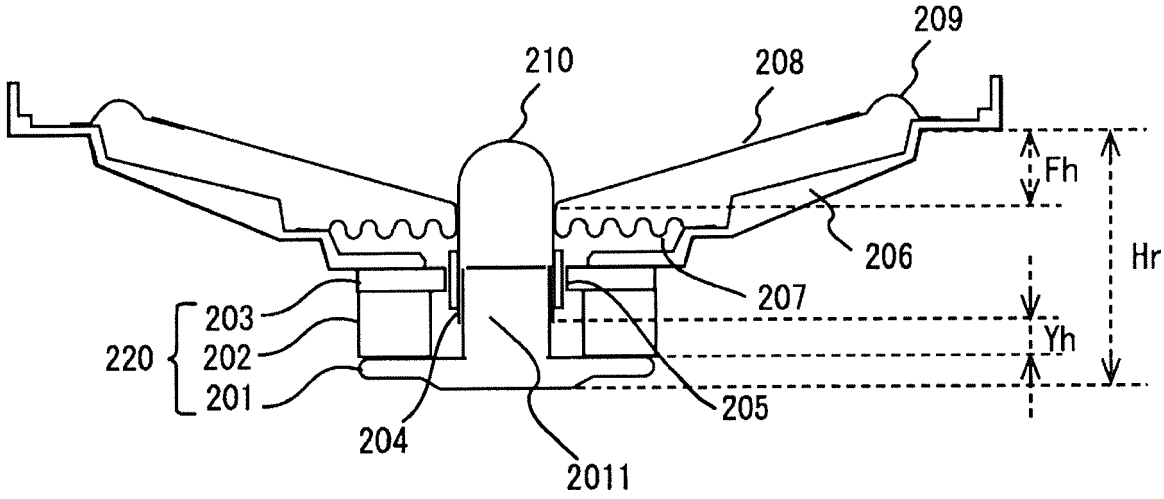
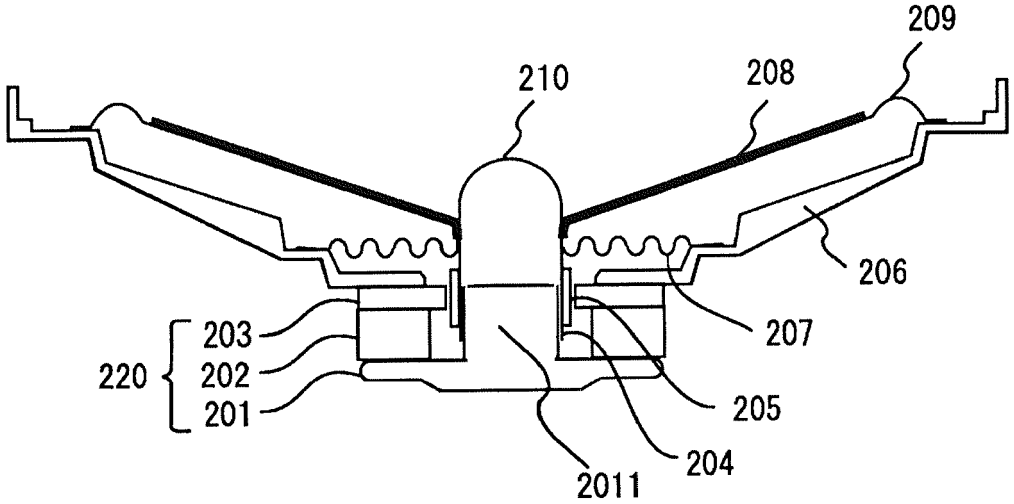

209
210
208
Fh
206
Hr
207
203
220
202
Yh
201
205
204
2011

FIG. 6B


209
210
208
206
207
203
220
202
205
201
204
2011

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 21 4712

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 03/001885 A2 (HARMAN INT IND [US]; IRACLIANOS SPIRO [US] ET AL.) 9 January 2003 (2003-01-09) * paragraph [0037]; figures 1,3 * -----	1-9	INV. H04R5/02 ADD. H04R9/06

TECHNICAL FIELDS SEARCHED (IPC)

H04R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 May 2019	Navarri, Massimo

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 21 4712

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-05-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03001885 A2	09-01-2003	AU 2002322338 A1	03-03-2003
		US 2004237111 A1	25-11-2004
		WO 03001885 A2	09-01-2003

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2007243430 A **[0003]**
- JP 2005311908 A **[0004]**