United States Patent Application Publication	20250267394
Kind Code	A1
Publication Date	August 21, 2025
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VEHICLE SPEAKER

Abstract

A vehicle speaker includes a vibration portion, a magnetic driver configured to drive the vibration portion, and a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed. A sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing. The sound pressure space includes a duct portion extending from a starting edge to the sound pressure opening, where the starting edge is an edge of the vibration portion closest to the sound pressure opening. A cross-sectional area of a space of the duct portion at the starting edge is larger than an area of the sound pressure opening.

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Family ID: **1000008436465**

Appl. No.: **19/036703**

Filed: **January 24, 2025**

Foreign Application Priority Data

JP	2024-021084	Feb. 15, 2024

Publication Classification

Int. Cl.: **H04R1/28** (20060101); **H04R9/02** (20060101); **H04R9/06** (20060101)

U.S. Cl.:

CPC **H04R1/2811** (20130101); **H04R9/025** (20130101); **H04R9/06** (20130101); H04R2400/11 (20130101); H04R2499/13 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application is based on and claims priority to Japanese Patent Application No. 2024-021084 filed on Feb. 15, 2024, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a vehicle speaker in which a sound pressure space partitioned by a vibration portion is formed in a housing and a sound pressure opening, through which the sound pressure space communicates with outside of the housing, is formed in the housing.

BACKGROUND

[0003] Japanese Unexamined Patent Application Publication Nos. 2013-118585 and 2019-125962 describe vehicle speakers used as so-called subwoofers or the like. In each of the above vehicle speakers, a sound generating unit including a diaphragm and a magnetic driver is disposed. A duct is integrally formed in a housing of the vehicle speaker, where the duct guides the sound pressure generated by vibrations of the diaphragm to outside of the housing, and a sound emission opening is formed in the duct. The housing including the diaphragm is installed in an external space of a vehicle, and the duct is attached to a hole formed in a partition wall of the vehicle. The sound pressure generated in the housing by vibrations of the diaphragm is radiated as a reproduced sound from the sound emission opening of the duct to the interior space of the cabin of the vehicle.

[0004] The vehicle speaker disclosed in Japanese Unexamined Patent Application Publication No. 2013-118585 includes the duct having a rectangular cross-sectional shape, where the cross-sectional area of the duct is uniform across the entire length in the longitudinal direction. The vehicle speaker disclosed in Japanese Unexamined Patent Application Publication No. 2019-125962 includes the duct having a so-called constricted shape where the cross-sectional area of the duct gradually decreases toward the sound emission opening until reaching a halfway point, and gradually increases from the halfway point toward the sound emission opening.

SUMMARY

[0005] According to one aspect of the present disclosure, a vehicle speaker includes a vibration portion, a magnetic driver configured to drive the vibration portion, and a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed. A sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing. The sound pressure space includes a duct portion extending from a starting edge to the sound pressure opening, where the starting edge is an edge of the vibration portion closest to the sound pressure opening. A cross-sectional area of a space of the duct portion at the starting edge is larger than an area of the sound pressure opening.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Objects and further features of the present disclosure will be apparent from the following detailed description when read in conjunction with the accompanying drawings, in which:

[0007] FIG. **1** is a plan view illustrating a vehicle speaker according to an embodiment of the present disclosure;

[0008] FIG. **2** is a side view illustrating the vehicle speaker according to the embodiment of the present disclosure;

[0009] FIG. **3** is a perspective view including a partial cross-section of the vehicle speaker

according to the embodiment of the present disclosure;
[0010] FIG. **4** is a horizontal cross-sectional view of the vehicle speaker according to the embodiment of the present disclosure;
[0011] FIG. **5** is an enlarged partial view of the horizontal cross-sectional view of FIG. **4**;
[0012] FIG. **6** is an enlarged partial view of the side view of FIG. **2**;
[0013] FIG. **7**A is a horizontal cross-sectional view illustrating a first modification example of the vehicle speaker of the present disclosure;
[0014] FIG. **7**B is a vertical cross-sectional view illustrating the first modification example of the vehicle speaker of the present disclosure;
[0015] FIG. **8**A is a horizontal cross-sectional view illustrating a second modification example of the vehicle speaker of the present disclosure;
[0016] FIG. **8**B is a vertical cross-sectional view illustrating the second modification example of the vehicle speaker of the present disclosure; and
[0017] FIG. **9** is a graph describing the frequency response of the vehicle speaker according to the embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] In the vehicle speakers disclosed in Japanese Unexamined Patent Application Publication Nos. 2013-118585 and 2019-125962, the sound generating unit including the diaphragm and the magnetic driver is accommodated in the housing, and the sound pressure generated by vibrations of the diaphragm affects the interior of the housing. Since the duct is formed in the housing, a mass of the air inside the duct serves as a load for vibrating the diaphragm, and therefore the response obtained by the sound generating unit becomes equivalent to a response obtained by the sound generating unit in which the mass of the diaphragm is increased. As a result, the lowest resonance frequency f**0** of the vibration portion is lowered. Therefore, a reproduction frequency band of the sound generating unit can be further expanded to a bass range when the sound generating unit is operated in a housing including a duct, compared with when the sound generating unit is operated without being accommodated in a housing. On the other hand, the duct may lower the reproduction sensitivity in the bass range and the sound pressure in the bass range may be reduced because an air flow in the duct increases the load energy at the time when the diaphragm is operated. For the above speakers, it is desired to design the shape of the housing and duct considering the balance between the above conflicting properties, i.e., expansion of reproduction frequencies toward the bass range, and enhancement of the sensitivity in the bass range.
[0019] A sound emission opening of a duct provided in a vehicle speaker needs to match with a hole formed in a partition wall that partitions an interior space of a cabin from an exterior space of the cabin. However, there is a limit in increasing the size of the hole of the partition wall. Therefore, an area of the sound emission opening of the duct cannot be increased significantly. The vehicle speaker disclosed in Japanese Unexamined Patent Application Publication No 2013-118585 includes the duct having a uniform cross-sectional area in the longitudinal direction. If the area of the sound emission opening of the duct is matched with the hole of the partition wall of a vehicle, a cross-sectional area at each position of the duct becomes small so that the integral value of the cross-sectional area across the entire duct also becomes small. Therefore, the load applied when the air moves in the duct is increased, and the sensitivity of the reproduction frequencies in the bass range is likely to be lowered. The vehicle speaker disclosed in Japanese Unexamined Patent Application Publication No. 2019-125962 includes the duct having the constricted shape where the cross-sectional area of the duct becomes small toward the sound emission opening until reaching the halfway point. Therefore, even in this duct shape, the load applied when the air moves in the duct is increased, and it is difficult to increase the sensitivity in the bass range.
[0020] The present disclosure aims to solve the above problems existing in the related art. An object of the present disclosure is to provide a vehicle speaker having a configuration by which an effect of expanding a reproduction frequency band to a bass range and an effect of increasing a

sensitivity in the bass range in a well-balanced manner without increasing an area of a sound pressure opening formed at a duct.

[0021] The vehicle speaker of the present disclosure includes a vibration portion, a magnetic driver configured to drive the vibration portion, and a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed. A sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing. The sound pressure space includes a duct portion extending from a starting edge to the sound pressure opening, where the starting edge is an edge of the vibration portion closest to the sound pressure opening. A cross-sectional area of a space of the duct portion at the starting edge is larger than an area of the sound pressure opening.

[0022] The vehicle speaker of the present disclosure may be configured such that, when the duct portion is divided into multiple sections by evenly dividing a distance from the starting edge to the sound pressure opening, among the multiple sections, an internal volume of a starting-edge-side section including the starting edge is larger than an internal volume of a sound-pressure-opening-side section including the sound pressure opening.

[0023] For example, when the duct portion is divided into two sections, i.e., the starting-edge-side section including the starting edge and the sound-pressure-opening-side section including the sound pressure opening, by bisecting the distance from the starting edge to the sound pressure opening, an internal volume of the starting-edge-side section is larger than an internal volume of the sound-pressure-opening-side section.

[0024] Alternatively, when the duct portion is divided into three sections, i.e., the starting-edge-side section including the starting edge, an intermediate section, and the sound-pressure-opening-side section including the sound pressure opening, by evenly dividing the distance from the starting edge to the sound pressure opening into three, an internal volume of the starting-edge-side section including the starting edge is larger than an internal volume of the sound-pressure-opening-side section including the sound pressure opening and an internal volume of the intermediate section.

[0025] The vehicle speaker of the present disclosure is preferably configured such that the cross-sectional area of the space of the duct portion gradually decreases from the starting edge toward the sound pressure opening.

[0026] Moreover, the present disclosure is characterized by a vehicle speaker that includes a vibration portion, a magnetic driver configured to drive the vibration portion, a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed. A sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing. When a virtual line passing through a center of the vibration portion and extending in a vibration direction of the vibration portion is determined as a vibration center line, and a line intersecting the vibration center line at a right angle and extending to a center of the sound pressure opening is determined as a plane center line, a width of the housing in a direction perpendicular to both vibration center line and the plane center line gradually decreases from a position of the vibration center line toward the sound pressure opening.

[0027] The vehicle speaker of the present disclosure is preferably configured such that a height of the housing projected onto a vertical plane parallel to both the vibration center line and the plane center line gradually decreases from the position of the vibration center line toward the sound pressure opening.

<Configuration of Vehicle Speaker **1**>

[0028] FIGS. **1** to **6** illustrate the vehicle speaker **1** according to an embodiment of the present disclosure. A partition wall **2** of a vehicle, such as a car, is illustrated in FIG. **2**, and an opening **3** is formed in the partition wall **2**. One of the spaces across the partition wall **2** is an interior cabin space S**1** that communicates with the cabin of the vehicle, and the other space is an exterior cabin space S**2** that communicates with the space outside the vehicle. The vehicle speaker **1** is installed in the interior cabin space S**1**, and the sound generated by vibrations of a diaphragm is radiated to the interior cabin space S**1**. The sound pressure opening **13** formed at a duct of the housing **10** of the vehicle speaker **1** is coupled to the opening **3**, and a sound pressure space inside the housing communicates with the exterior cabin space S**2**. In contrast to FIG. **2**, the vehicle speaker **1** may be installed in the exterior cabin space S**2**, and the sound pressure opening **13** of the duct may be coupled to the opening **3**. In the installation example as mentioned, the sound pressure space in the housing communicates with the interior cabin space S**1** via the duct, and the sound pressure opening **13** of the duct functions as a sound emission opening for emitting sound to the interior cabin space S**1**.

[0029] As illustrated in FIG. **3**, the vehicle speaker **1** includes the diaphragm **31**, which is a constituent component of a vibration portion **30**, in the housing, and the diaphragm **31** is characterized by a vibration center line Ov that is a virtual line passing through the center of the diaphragm **31** and extends in the vibration direction of the diaphragm **31**. The Z**1**-Z**2** direction is a vertical direction (up-down direction) parallel to the vibration center line Ov, the Z**1** direction is an upward direction, and the Z**2** direction is a downward direction. Moreover, the **22** direction is a sound emission direction when the diaphragm **31** vibrates. As illustrated in FIG. **4**, a line intersecting the vibration center line Ov at a right angle and extending to the center of the sound pressure opening **13** of the housing **10** is a plane center line Oh. The X**1**-X**2** direction is a longitudinal direction parallel to the plane center line Oh, the X**1** direction is the direction toward the inside of the housing, and the X**2** direction is the direction in which the sound pressure is released from the duct. The Y**1**-Y**2** direction is a widthwise direction intersecting with both the vibration center line Ov and the plane center line Oh at a right angle. FIG. **1** and FIG. **4** are respectively a plan view and a horizontal cross-sectional view, in which the vehicle speaker **1** is projected onto a plane (X-Y plane) perpendicular to the vibration center line Ov. FIG. **2** is a side view in which the vehicle speaker **1** is projected onto a vertical plane (X-Z plane) parallel to both the vibration center line Ov and the plane center line Oh.

[0030] FIG. **3** illustrates an internal configuration of the vehicle speaker **1**. The vehicle speaker **1** includes the housing **10**. The housing **10** is formed by die-casting a metal material or injection-molding a reinforced plastic material. A substantially circular opening **12** is formed in a bottom portion **11** of the housing **10** facing the downward direction (Z**2** direction). The housing **10** is provided with an upper frame **21** and a lower frame **25**, which face the opening **12**. The outer circumference **22** of the upper frame **21** and the outer circumference **26** of the lower frame **25** are vertically stacked, and are secured, by screwing, to the lower side of the bottom portion **11** of the housing **10** at the peripheral portion of the opening **12**. A plurality of windows **23** are opened in the upper frame **21**, and a plurality of windows **27** are also opened in the lower frame **25**.

[0031] As illustrated in FIG. **3**, the vibration portion **30** is disposed at a position facing the opening **12** in the housing **10**. The vibration portion **30** includes a cone-shaped diaphragm **31** that mainly contributes to generation of the sound pressure, and an edge member **32** bonded to the outer circumference of the diaphragm **31**. The edge member **32** has a semi-circular cross-section and a ring shape when projected onto a plane. The inner circumference **32***a* of the edge member **32** is secured onto the outer circumference **31***a* of the diaphragm **31** by bonding, and the outer circumference **32***b* of the edge member **32** is interposed between the outer circumference **22** of the upper frame **21** and the outer circumference **26** of the lower frame **25**, and is secured to the peripheral portion of the opening **12** of the housing **10**.

[0032] As illustrated in FIG. **3**, a center hole **31***b* is formed in the center of the cone-shaped diaphragm **31**, and a cylindrical bobbin **33** is secured to the inside of the center hole **31***b*. A voice coil **34** is wound around and fixed to the outer circumference of the lower portion of the bobbin **33**. The opening at the top of the bobbin **33** is sealed with a cap **35**. Damper members **36** and **37** are provide inside the housing **10**. Each of the damper members **36** and **37** has a circular shape as a shape projected onto a plane, and has a corrugated cross-section. The outer circumference of each of the damper members **36** and **37** is bonded to and secured onto an upper support **24** of the upper frame **21**, and the inner circumference of each of the damper members **36** and **37** is bonded to and secured onto the outer circumferential surface of the bobbin **33**. The diaphragm **31** is supported by the edge member **32**, and the damper members **36** and **37**, and can vibrate in the vertical direction along the vibration center line Ov by elastic deformation of the edge member **32** and the damper members **36** and **37**.

[0033] As illustrated in FIG. **3**, a magnetic circuit **40** is supported by the central portion **28** of the lower frame **25**. The magnetic circuit **40** includes a lower yoke **41** having a center pole **41***a* formed of a magnetic metallic material, a ring-shaped magnet **42** secured on the outer circumference of the lower yoke **41**, and a ring-shaped upper yoke **43** that is secured onto the upper surface of the magnet **42** and is formed of a magnetic metallic material. The upper surface of the upper yoke **43** is secured to the lower surface of the central portion **28** of the lower frame **25**. A magnetic gap G is formed between the outer circumferential surface of the center pole **41***a* of the lower yoke **41** and the inner circumferential surface of the upper yoke **43**, and the voice coil **34** provided on the lower outer circumference of the bobbin **33** is positioned inside the magnetic gap G.

[0034] In the magnetic circuit **40**, a magnetic flux crossing the magnetic gap G is formed. The voice current flowing through the voice coil **34** positioned inside the magnetic gap G and the magnetic flux crossing the voice coil **34** inside the magnetic gap G generate an electromagnetic force, which applies a vertical vibration force to the vibration portion **30** via the voice coil **34**. The magnetic circuit **40** and the voice coil **34** constitute a "magnetic driver."

[0035] The opening **12** formed in the bottom portion **11** of the housing **10** is sealed with the cap **35** that seals the top of the vibration portion **30** comprised of the diaphragm **31** and the edge member **32** and the top of the bobbin **33**. As illustrated in FIG. **4**, the housing **10** is provided with the sound pressure opening **13** that opens in the X**2** direction. The inside of the housing **10** is a sound pressure space Sv that is completely partitioned by the vibration portion **30** and the cap **35** sealing the opening **12**, and the sound pressure space Sv communicates with the space outside the housing **10** only through the sound pressure opening **13**.

[0036] As illustrated in FIG. **2**, the housing **10** of the vehicle speaker **1** is installed in the interior cabin space S**1**, and the sound pressure opening **13** is secured inside the opening **3** formed in the partition wall **2**. As the diaphragm **31** vibrates, the generated sound pressure acts on the interior cabin space S**1** through the windows **27** formed in the lower frame **25**, thereby reproducing a sound in the interior cabin space S**1**. As the diaphragm **31** vibrates, a back pressure in antiphase to the sound pressure acting on the cabin interior space S**1** acts on the sound pressure space Sv in the housing **10**, but the back pressure is applied to the exterior cabin space S**2** through the sound pressure opening **13**.

<Shape of Sound Pressure Space Sv>

[0037] FIG. **4** illustrates the internal configuration of the sound pressure space Sv inside the housing **10** as a horizontal cross-sectional view projected onto a plane (X-Y plane) perpendicular to the vibration center line Ov. Within the sound pressure space Sv, a planar region, onto which the vibration portion **30** including the diaphragm **31** and the edge member **32** is projected, is a sound pressure acting portion P that directly receives the air pressure generated by vibrations of the vibration portion **30**. Within the sound pressure space Sv, the region other than the sound pressure acting portion P, i.e., the region Sd indicated by hatching in FIG. **5**, is a region for guiding the air pressure that has acted on the sound pressure acting portion P to the sound pressure opening **13**. In the following description, within the region Sd indicated by hatching in FIG. **5**, an edge of the vibration portion **30** closest to the sound pressure opening **13** is determined as a starting edge **30**E, and a region from the starting edge **30**E to the sound pressure opening **13** is described as a duct portion D.

[0038] As illustrated in FIG. **4**, the width of the housing **10** in the Y**1**-Y**2** direction perpendicular to both the vibration center line Ov and the plane center line Oh gradually decreases from the position of the vibration center line Ov toward the center of the sound pressure opening **13**. The sound pressure space Sv inside the housing **10** has the largest width Wo at the vibration center line Ov and the smallest width We at the center of the sound pressure opening **13**. The width of the sound pressure space Sv gradually decreases in a linear function manner from the largest width Wo to the smallest width We. Note that the width of the sound pressure space Sv may gradually decrease in a quadratic function manner from the largest width Wo to the smallest width We. As illustrated in FIG. **2**, the height of the housing **10** projected onto a vertical plane parallel to both the vibration center line Ov and the plane center line Oh is the largest Ho at the position of the vibration center line Ov and the smallest He at the center of the sound pressure opening. The height of the housing **10** gradually decreases from the maximum height Ho to the minimum height He.

[0039] In FIGS. **5** and **6**, within the duct portion D that is a part of the sound pressure space Sv, a cross-section passing through the starting edge **30**E is indicated by Ds, and a cross-section passing through the center of the sound pressure opening **13** is indicated by Do. Moreover, an intermediate cross-section at an intermediate position that bisects a distance from the cross-section Ds to the cross-section Do in the X direction is indicated by Dh. A cross-sectional area of the space in the duct portion D at the cross-section Ds is indicated by As, a cross-sectional area of the space of the duct portion D at the intermediate cross-section Dh is indicated by Ah, and a cross-sectional area of the space of the duct portion D at the cross-section Do is indicated by Ao.

[0040] As illustrated in FIG. **6**, a portion where the duct portion D of the housing **10** is formed is slightly curved to descend toward the sound pressure opening **13**. The cross-sectional areas As, Ah, and Ao are vertical cross-sectional areas of the duct portion D at the positions of Ps, Ph, and Po illustrated in FIG. **6**, respectively. That is, when a vertical line passing through centers of arbitrary cross-sections aligned in the X direction is determined as a duct center line Ox, each of the cross-sections Ds, Dh, and Do is a plane perpendicular to a tangent line of the duct center line Ox, and each of the cross-sectional areas As, Ah, and Ao is a cross-sectional area on the plane perpendicular to the tangent line of the duct center line Ox. Alternatively, each of the cross-sectional areas As, Ah, and Ao is an area of the cross-section with which the cross-sectional area becomes the smallest among the cross-sections passing through the respective position of Ps, Ph, or Po. A grid **15** for dustproofing is provided to the sound pressure opening **13**. Alternatively, a perforated plate or a net may be provided. The cross-sectional area Ao at the cross-section Do passing through the center of the sound pressure opening **13** is a cross-sectional area with assumption that the grid **15**, perforated plate, or net is not present, and the cross-sectional area Ao is an opening area of the sound pressure opening **13**.

[0041] The shape of the space of the duct portion D that is a part of the sound pressure space Sv is such that the cross-sectional area As of the internal space of the duct portion D at the cross-section Ds passing through the starting edge **30**E is larger than the cross-sectional area Ao of the space at the cross-section Do passing through the center of the sound pressure opening **13**. The cross-sectional area Ah of the space at the intermediate cross-section Dh is smaller than the cross-sectional area As, and is larger than the cross-sectional area Ao. The cross-sectional area of the duct portion D is the smallest at Ao, and becomes larger in the order of Ah and then As (As>Ah>Ao). The cross-sectional area of the space of the duct portion D gradually decreases from the cross-sectional area As to the cross-sectional area Ao.

[0042] As illustrated in FIGS. **5** and **6**, when the inside of the duct portion D is divided into a starting-edge-side section N**1** including the starting edge **30**E, which is from the cross-section Ds to the intermediate cross-section Dh, and a sound-pressure-opening-side section N**2** including the sound pressure opening **13**, which is from the intermediate cross-section Dh to the cross-section Do, the internal volume of the starting-edge-side section N**1** is larger than the internal volume of the sound-pressure-opening-side section N**2**. As illustrated in FIG. **5**, moreover, when the inside of the duct portion D is divided into three sections in the X direction, i.e., a starting-edge-side section Na including the starting edge **30**E, a sound-pressure-opening-side section Nc including the sound pressure opening **13**, and an intermediate section Nb, the internal volume of the starting-edge-side section Na is larger than the internal volume of the sound-pressure-opening-side section Nc and is larger than the internal volume of the intermediate section Nb. Moreover, the internal volume decreases in the order of the starting-edge-side section Na, the intermediate section Nb, and the sound-pressure-opening-side section Nc. That is, when the duct portion D is divided into multiple sections by evenly dividing the distance in the X direction from the starting edge **30**E to the sound pressure opening **13**, the internal volume of the starting-edge-side section including the starting edge **30**E is larger than the internal volume of the sound-pressure-opening-side section including the sound pressure opening **13**.

<Acoustic Effect>

[0043] The sound pressure space Sv, which is the internal space of the housing **10**, includes the region Sd indicated by hatching in parallel with the sound pressure acting portion P that directly receives the air pressure generated by vibrations of the vibration portion **30**. The region Sd is a region for guiding the air pressure that has acted on the sound pressure acting portion P to the sound pressure opening **13**, and part of the region Sd constitutes the duct portion D. A mass of the air inside the region Sd and the duct portion D serves as a load mass when the vibration portion **30** is operated, and the response obtained by the reproducing unit including the vibration portion **30** and the magnetic circuit **40** is equivalent to a response obtained when the mass of the vibration portion **30** is increased. Therefore, the lowest resonance frequency f**0** of the vibration portion is lowered, which can expand the reproduction frequencies to the bass range.

[0044] The housing **10** and the duct portion D have the following characteristics.

[0045] (a) The sound pressure space Sv inside the housing **10** has the largest width Wo at the center line Ov, and the smallest width We at the center of the sound pressure opening **13**, and the width of the sound pressure space Sv gradually decreases from the largest width Wo to the smallest width We. The height of the housing **10** gradually decreases from the maximum height Ho to the minimum height He.

[0046] (b) The cross-sectional area of the duct portion D satisfies As>Ao, and As>Ah>Ao.

[0047] (c) When the duct portion D is divided into multiple sections by evenly dividing the distance from the starting edge **30**E to the sound pressure opening **13** in the X direction, an internal volume of the starting-edge-side section including the starting edge **30**E is larger than an internal volume of the sound-pressure-opening-side section including the sound pressure opening **13**.

[0048] When the vibration portion **30** vibrates and the air flows into the duct portion D, the smaller the cross-section of the duct portion D is, the larger the resistance force is, and as the value obtained by integrating the areas of the cross-sections in the X direction across the entire length of the duct decreases, the load energy of the air flowing the entire area inside the duct portion D increases. As the load energy increases, the dynamic resistance of the vibration portion **30** increases, the sensitivity in the bass range decreases, and the generated sound pressure in the bass range decreases. The opening **3** formed in the partition wall **2** illustrated in FIG. **2** is determined by a type of vehicle, and therefore the area of the sound pressure opening **13** is limited. In the vehicle speaker **1** of the present embodiment, as described in (a), (b), and (c) above, the cross-sectional area or the volume of the sound pressure space Sv is set to increase from the sound pressure opening **13** toward the inside of the housing **10**, and therefore the volume obtained by integrating the areas of the cross-sections of the duct portion D of the duct portion in the X direction across the entire length of the duct portion becomes large. Thus, the load energy applied when the vibration portion **30** vibrates can be reduced, and the sensitivity in the bass range is increased so that the reproduced sound pressure in the bass range can be increased.

[0049] The graph of FIG. **9** depicts the simulation results of the frequency response (i) of the vehicle speaker **1** of the embodiment of the present disclosure, the frequency response (ii) of Comparative Example 1, and the frequency response (iii) of Comparative Example 2. The horizontal axis of the graph represents a reproduction frequency (Hz), and the vertical axis of the graph represents reproduction sound pressure (dB). In Comparative Example 1, the reproducing unit including the vibration portion **30**, the magnetic circuit **40**, and the damper members **36** and **37** illustrated in FIG. **3** are simply secured on the baffle and operated without being accommodated in the housing **10**. In Comparative Example 2, a speaker having the housing **10** illustrated in FIGS. **1** and **2**, in which the cross-sectional area of the space of the duct portion D is made uniform without changing from the area of the sound pressure opening **13** across the entire length, is operated.

[0050] According to the simulation results depicted in FIG. **9**, the frequency response (i) of the vehicle speaker **1** having the duct portion and the frequency response (iii) of Comparative Example 2 could expand the frequency band of the reproduction frequencies to a frequency band F usable as a subwoofer, such as a region of 100 Hz or lower, compared with the frequency response (ii) of Comparative Example 1 in which the reproducing unit was attached to the baffle. Moreover, the frequency response (i) of the vehicle speaker **1** of the embodiment had a high sensitivity in the bass range that was the usable frequency band F, compared with the frequency response (iii) of Comparative Example 2 having the duct portion with the uniform cross-sectional area.

Modification Example

[0051] The vehicle speaker **101** of the first modification example of FIGS. **7**A and **7**B has a planar shape of the duct portion D that has a constant width from the starting edge **30**E to the intermediate point, from which the width gradually decreases toward the sound pressure opening **13**, as illustrated in FIG. **7**A. As illustrated in FIG. **7**B, the height of the duct portion D is uniform in the side view shape. The duct portion D is configured such that the internal volume of the starting-edge-side section N**1** is larger than the internal volume of the sound-pressure-opening-side section N**2**. The vehicle speaker **201** of the second modification example of FIGS. **8**A and **8**B has a planar shape of the duct portion D that has a constant width across the entire length from the starting edge **30**E to the sound pressure opening **13**, as illustrated in FIG. **8**A. As illustrated in FIG. **8**B, the height of the duct portion D increases from the starting edge **30**E to the intermediate point, from which the height gradually decreases to have a small height at the sound pressure opening **13** in the side view shape. In the second modification example, the duct portion D is also configured such that the internal volume of the starting-edge-side section N**1** is larger than the internal volume of the sound-pressure-opening-side section N**2**.

[0052] In the duct portion D of the vehicle speaker **101** of the first modification example and the duct portion D of the vehicle speaker **201** of the second modification example, the internal volume of the starting-edge-side section N**1** is larger than the internal volume of the sound-pressure-opening-side section N**2**. Moreover, the cross-sectional area of the space of the duct portion D at the cross-section passing through the starting edge **30**E is larger than the cross-sectional area of the space passing through the center of the sound pressure opening **13**. Therefore, an effect of expanding a usable band of reproduction frequencies to a bass range and an effect of increasing the sensitivity in the bass range can be easily set in a well-balanced manner.

[0053] The vehicle speaker of the present disclosure can easily achieve both an effect of expanding a usable band of reproduction frequencies to a bass range and an effect of increasing the sensitivity in the bass range by increasing a cross-sectional area and internal volume of a duct portion at a starting edge, i.e., the vicinity of an inner position of a housing, even if a cross-sectional area and internal volume of the duct adjacent to the sound pressure opening are small. Further, the vehicle speaker of the present disclosure can easily achieve both an effect of expanding a usable band of reproduction frequencies to a bass range and an effect of increasing the sensitivity in the bass range by making the shape of the housing large at a central portion of the vibration portion and gradually decreasing the dimensions of the housing toward the sound pressure opening as viewed in a plan view or as viewed in a vertical view.

[0054] Although the vehicle speaker of the present disclosure has been described with reference to the above embodiments, the present disclosure is not limited to the above embodiments, and various variations and modifications may be made without departing from the scope of the present disclosure.

Claims

1. A vehicle speaker comprising: a vibration portion; a magnetic driver configured to drive the vibration portion; and a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed, wherein a sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing, wherein the sound pressure space includes a duct portion that extends from a starting edge to the sound pressure opening, where the starting edge is an edge of the vibration portion closest to the sound pressure opening, and a cross-sectional area of a space of the duct portion at the starting edge is larger than an area of the sound pressure opening.
2. The vehicle speaker according to claim 1, wherein when the duct portion is divided into multiple sections by evenly dividing a distance from the starting edge to the sound pressure opening, among the multiple sections, an internal volume of a starting-edge-side section including the starting edge is larger than an internal volume of a sound-pressure-opening-side section including the sound pressure opening.
3. The vehicle speaker according to claim 2, wherein, when the duct portion is divided into two sections, which are the starting-edge-side section including the starting edge and the sound-pressure-opening-side section including the sound pressure opening, by bisecting the distance from the starting edge to the sound pressure opening, an internal volume of the starting-edge-side section including the starting edge is larger than an internal volume of the sound-pressure-opening-side section including the sound pressure opening.
4. The vehicle speaker according to claim 2, wherein, when the duct portion is divided into three sections, which include the starting-edge-side section including the starting edge, an intermediate section, and the sound-pressure-opening-side section including the sound pressure opening, by evenly dividing the distance from the starting edge to the sound pressure opening into three, an internal volume of the starting-edge-side section including the starting edge is larger than an internal volume of the sound-pressure-opening-side section including the sound pressure opening, and is larger than an internal volume of the intermediate section.
5. The vehicle speaker according to claim 1, wherein the cross-sectional area of the space of the duct portion gradually decreases from the starting edge toward the sound pressure opening.
6. A vehicle speaker comprising: a vibration portion; a magnetic driver configured to drive the vibration portion; and a housing in which the vibration portion and the magnetic driver are accommodated, and a sound pressure opening is formed, wherein a sound pressure space partitioned by the vibration portion and communicating with the sound pressure opening is formed in the housing, and wherein, when a virtual line passing through a center of the vibration portion and extending in a vibration direction of the vibration portion is determined as a vibration center line, and a line intersecting the vibration center line at a right angle and extending to a center of the sound pressure opening is determined as a plane center line, a width of the housing in a direction perpendicular to both the vibration center line and the plane center line gradually decreases from a position of the vibration center line toward the sound pressure opening.
7. The vehicle speaker according to claim 6, wherein a height of the housing projected onto a vertical plane parallel to both the vibration center line and the plane center line gradually decreases from the position of the vibration center line toward the sound pressure opening.