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United States Patent	12389145
Kind Code	B2
Date of Patent	August 12, 2025
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Loudspeaker system and seat

Abstract

A loudspeaker system includes: a loudspeaker; a loudspeaker box provided inside a seat, and in which the loudspeaker is provided; and an actuator. The actuator is provided inside the loudspeaker box to cause a baffle panel of the loudspeaker box to generate vibration.

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Appl. No.: **18/371909**

Filed: **September 22, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20240107211 A1	Mar. 28, 2024

Foreign Application Priority Data

JP	2022-155130	Sep. 28, 2022

Publication Classification

Int. Cl.: **H04R1/02** (20060101); **H04R1/26** (20060101); **H04R1/28** (20060101); **H04R5/02** (20060101); **H04R7/04** (20060101)

U.S. Cl.:

CPC **H04R1/025** (20130101); **H04R1/26** (20130101); **H04R1/2811** (20130101); **H04R5/023** (20130101); **H04R7/04** (20130101); H04R2440/05 (20130101); H04R2460/13 (20130101); H04R2499/13 (20130101)

Field of Classification Search

CPC: H04R (1/025); H04R (1/24); H04R (1/26); H04R (1/2811); H04R (5/02); H04R (5/023); H04R (7/04); H04R (7/045); H04R (2440/05); H04R (2460/13); H04R (2499/13)

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION

(1) The present application is based on and claims priority of Japanese Patent Application No. 2022-155130 filed on Sep. 28, 2022.

FIELD

(2) The present disclosure relates to a loudspeaker system and a seat.

BACKGROUND

(3) Patent Literature (PTL) 1 discloses a seat in which a loudspeaker is embedded. Accordingly, sound can be outputted from the seat to a person seated on the seat.

CITATION LIST

Patent Literature

(4) PTL 1: Japanese Unexamined Utility Model (Registration) Application Publication No. 60-93387

SUMMARY

(5) However, the system disclosed in PTL 1 can be improved upon.

(6) In view of this, the present disclosure provides a loudspeaker system, and so on, capable of improving upon the above related art.

(7) A loudspeaker system according to an aspect of the present disclosure includes: a loudspeaker; a loudspeaker box provided inside a seat, and in which the loudspeaker is provided; and an actuator, wherein the actuator is provided inside the loudspeaker box to cause a baffle panel of the loudspeaker box to generate vibration.

(8) A seat according to an aspect of the present disclosure includes the above-described loudspeaker system.
(9) A loudspeaker system, and so on, according to an aspect of the present disclosure is capable of improving upon the above related art.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) These and other advantages and features of the present disclosure will become apparent from the following description thereof taken in conjunction with the accompanying drawings that illustrate a specific embodiment of the present disclosure.
(2) FIG. **1** illustrates a front view of an example of a seat according to Embodiment 1.
(3) FIG. **2**A illustrates a front view and a cross-sectional view of an example of a loudspeaker system according to Embodiment 1.
(4) FIG. **2**B illustrates a front view and a cross-sectional view of an example of a loudspeaker system according to Embodiment 1.
(5) FIG. **2**C illustrates a front view and a cross-sectional view of an example of a loudspeaker system according to Embodiment 1.
(6) FIG. **2**D illustrates a front view and a cross-sectional view of an example of a loudspeaker system according to Embodiment 1.
(7) FIG. **3** is a graph illustrating an example of frequency response of sounds (sound pressure) outputted from a loudspeaker and an actuator included in a loudspeaker system according to Embodiment 1.
(8) FIG. **4** is a block diagram illustrating an example of a signal processing device according to Embodiment 2.
(9) FIG. **5** is a block diagram illustrating an example of a signal processing device according to Embodiment 3.
(10) FIG. **6** is diagram illustrating an example of filter characteristics of a low pass filter included in an outputter according to Embodiment 3.
DESCRIPTION OF EMBODIMENTS
(11) In recent years, seats in which loudspeakers and actuators are embedded have been developed, and it has become possible to reproduce sound from the loudspeakers and give vibration corresponding to the sound by the actuators to the persons seated on the seats. However, there are cases where it is not possible to provide powerful sound and vibration to persons seated on the seats.
(12) Thus, a loudspeaker system, and so on, that can provide powerful sound and vibration to a person seated on a seat will be described below.
(13) Hereinafter, exemplary embodiments will be described in detail with reference to the Drawings.
(14) It should be noted that each of the exemplary embodiments described hereinafter shows a general or specific example. Numerical values, shapes, materials, structural components, the arrangement and connection of the structural components, and so on, are mere examples, and thus are not intended to limit the present disclosure.
Embodiment 1
(15) Hereinafter, a loudspeaker system and a seat in which the loudspeaker system is provided according to Embodiment 1 will be described with reference to the drawings.
(16) FIG. **1** is a front view illustrating an example of seat **100** according to Embodiment 1.
(17) Seat **100** is a seat that is placed in, for example, a moving body such as a vehicle, an aircraft, and a ship. Note that seat **100** is not limited to a seat that is placed in a cabin of the moving body,

and may be a seat that is placed in a movie theater, a theater, or a conference room, a chair with a cushion, a legless chair, a sofa, a massage chair or the like.
(18) Seat **100** includes seat back **110**, seat surface **120**, and headrest **130**. Seat back **110** is a part that supports a back of a person and so on when the person is seated on seat **100**. Seat surface **120** is a part that supports thighs and so on of a person when the person is seated on seat **100**. Headrest **130** is a part that supports a head and so on of a person when the person is seated on seat **100**.
(19) Seat **100** is provided with one or more loudspeakers and one or more actuators. The loudspeaker is a device that converts electric signals into sound, and the actuator is a device that converts electric signals into a physical motion (for example, vibration). For example, the one or more actuators include a first actuator that is provided inside seat surface **120** of seat **100** at a position corresponding to thighs of a person in seat surface **120** when the person is seated on seat **100**, or a second actuator provided inside seat back **110** of seat **100** at a position corresponding to a sacrum of the person in seat back **110**. For example, the one or more loudspeakers include a first loudspeaker that is provided inside seat back **110** of seat **100** at a position corresponding to an abdominal region of the person in seat back **110** when the person is seated on seat **100**, a second loudspeaker that is provided inside seat back **110** of seat **100** at a position corresponding to a back of the person in seat back **110**, a third loudspeaker that is provided inside headrest **130** of seat **100**, or tweeter **600** that is attached to headrest **130**.
(20) For example, seat **100** includes loudspeaker systems **200**, **400**, and **500**, actuator system **300**, and tweeters **600**. For example, the one or more loudspeakers are included in loudspeaker systems **200**, **400**, and **500**, and the one or more actuators are included in loudspeaker system **200** and actuator system **300**. For example, loudspeaker systems **200** and **400** are provided inside seat back **110**, and actuator system **300** is provided inside seat surface **120**, and loudspeaker systems **500** are provided inside headrest **130**.
(21) Loudspeaker system **200** includes loudspeaker **201**, loudspeaker box **202** provided with loudspeaker **201**, and actuator **203**. Actuator **203** is provided in loudspeaker box **202** to cause a baffle panel of loudspeaker box **202** to generate vibration (see FIG. **2**A described later).
(22) Loudspeaker box **202** is provided inside seat **100**, and, for example, provided inside seat back **110**. For example, as illustrated in FIG. **1**, loudspeaker box **202** is provided inside seat back **110** of seat **100** at a position that is below a center in seat back **110**. Accordingly, it is possible to give powerful vibration by actuator **203** in loudspeaker box **202** to an area around the abdominal region and buttocks of a person seated on seat **100**. Furthermore, when heavy bass sound is outputted from loudspeaker **201**, it is possible to expose the area around the abdominal region and buttocks of the person seated on seat **100** to a sound wave of heavy bass sound from loudspeaker **201** in loudspeaker box **202**, and it is possible to provide powerful sound with vibration. Loudspeaker box **202** is a member in a rectangular parallelepiped shape, for example, and is formed from wood, resin, metal or the like.
(23) Actuator **203** is provided at a position below loudspeaker **201** in seat back **110**, for example. Accordingly, it is possible to give powerful vibration by actuator **203** to the area around the buttocks of the person seated on seat **100**. Specifically, actuator **203** is provided at a position corresponding to a sacrum of the person in seat back **110** when the person is seated on seat **100**, for example. Accordingly, it is possible to give powerful vibration by actuator **203** to the sacrum of the person seated on seat **100**. Actuator **203** is an example of the second actuator. Actuator **203** is capable of reproducing sounds from 40 Hz to 90 Hz (in other words, capable of generating low frequency vibration from 40 Hz to 90 Hz), for example. For example, actuator **203** is monaurally driven. Note that a plurality of actuators **203** may be provided in loudspeaker box **202**.
(24) Loudspeaker **201** is provided, for example, at a position corresponding to abdominal region of a person in seat back **110** when the person is seated on seat **100**. Accordingly, when heavy bass sound is outputted from loudspeaker **201**, it is possible to expose the abdominal region of the person seated on seat **100** to a sound wave of heavy bass sound, and it is possible to provide

powerful sound with vibration. Loudspeaker **201** is an example of the first loudspeaker. For example, loudspeaker **201** is a woofer, and capable of reproducing sound in a band from 40 Hz to 150 Hz. For example, loudspeaker **201** is monaurally driven. Note that a plurality of loudspeakers **201** may be provided in loudspeaker box **202**. Furthermore, a plurality of loudspeaker systems **200** may be provided in seat back **110**.

(25) Loudspeaker system **200** can give vibration while exposing the person seated on seat **100** to a sound wave from seat back **110** of seat **100**.

(26) Actuator system **300** includes actuator **301** and vibration plate **302**.

(27) Actuator **301** is provided at a position corresponding to thighs of a person in seat surface **120** of seat **100** when the person is seated on seat **100**. Actuator **301** is an example of the first actuator. Actuator **301** is fixed to vibration plate **302** to cause vibration plate **302** to generate vibration. Vibration plate **302** is provided inside seat surface **120**. Vibration plate **302** is, for example, a member in a rectangular plate shape, and is formed from wood, resin, metal or the like. Actuator system **300** can give vibration to the person seated on seat **100** from seat surface **120** of seat **100**. Actuator **301** is capable of reproducing sound from 40 Hz to 90 Hz (in other words, capable of generating low frequency vibration from 40 Hz to 90 Hz), for example. For example, actuator **301** is monaurally driven. Note that at vibration plate **302**, only one actuator **301** may be provided, or three or more actuators **301** may be provided.

(28) Loudspeaker system **400** includes loudspeakers **401**, and loudspeaker box **402** in which loudspeakers **401** are provided.

(29) Loudspeaker box **402** is provided inside seat **100**, and is provided inside seat back **110**, for example. For example, as illustrated in FIG. **1**, loudspeaker box **402** is provided in seat back **110** of seat **100** at a position that is above a center in seat back **110**. Loudspeaker box **402** is a member in a rectangular parallelepiped shape, for example, and is formed from wood, resin, metal or the like.

(30) Loudspeaker **401** is provided at a position corresponding to a back of a person in seat back **110** when the person is seated on seat **100**, for example. Loudspeaker **401** is an example of the second loudspeaker. For example, loudspeaker **401** is a full-range loudspeaker, and capable of reproducing sound in a band from 150 Hz to 800 Hz. For example, loudspeaker **401** is monaurally driven. Note that in loudspeaker box **402**, only one loudspeaker **401** may be provided, or three or more loudspeakers **401** may be provided. Furthermore, a plurality of loudspeaker systems **400** may be provided in seat back **110**.

(31) Loudspeaker system **400** can expose the person seated on seat **100** to a sound wave from seat back **110** of seat **100**.

(32) Loudspeaker system **500** includes loudspeaker **501** and loudspeaker box **502** in which loudspeaker **501** is provided.

(33) Loudspeaker box **502** is provided inside seat **100**, and provided inside headrest **130**, for example. Loudspeaker box **502** is a member in a rectangular parallelepiped shape, for example, and is formed from wood, resin, metal or the like.

(34) Loudspeaker **501** is provided at a position corresponding to the head of a person in headrest **130** when the person is seated on seat **100**, for example. Loudspeaker **501** is an example of the third loudspeaker. For example, loudspeaker **501** is a full-range loudspeaker, and capable of reproducing sound in a band from 350 Hz to 20 kHz. As illustrated in FIG. **1**, for example, two loudspeaker systems **500** are provided in headrest **130**, and two loudspeaker systems **500** are stereophonically driven. Note that a plurality of loudspeakers **501** may be provided in loudspeaker box **502**. Furthermore, in headrest **130**, only one loudspeaker system **500** may be provided, or three or more loudspeaker systems **500** may be provided.

(35) Loudspeaker system **500** can expose the person seated on seat **100** to a sound wave from headrest **130** of seat **100**.

(36) Tweeter **600** is provided at headrest **130**. For example, tweeter **600** is capable of reproducing sound in a band from 20 kHz to 100 kHz. As illustrated in FIG. **1**, for example, two tweeters **600**

are provided at headrest **130**, and two tweeters **600** are stereophonically driven. Note that at headrest **130**, only one tweeter **600** may be provided, or three or more tweeters **600** may be provided.

(37) The person seated on seat **100** can be exposed to sound waves from headrest **130** of seat **100** by tweeter **600**.

(38) Note that by signal processing device **10** according to Embodiment 2 or signal processing device **40** according to Embodiment 3 that will be described later, ultrasonic waves may be outputted from loudspeaker **501** or tweeter **600**, and in this case, a person seated on seat **100** can be exposed to ultrasonic waves from headrest **130** of seat **100**.

(39) Furthermore, by signal processing device **10** according to Embodiment 2 described later, actuator **203** generates vibration corresponding to an acoustic signal included in data of one track among data of a plurality of tracks that constitute a musical piece, and loudspeaker **201** may reproduce an acoustic signal included in data of another track of data of the plurality of tracks. Specifically, actuator **203** generates vibration corresponding to an acoustic signal of a kick drum included in data of a track of a drum among the data of the plurality of tracks, and loudspeaker **201** may reproduce an acoustic signal included in data of a track other than a drum track among the data of the plurality of tracks.

(40) Furthermore, by signal processing device **40** according to Embodiment 3 described later, actuator **203** generates vibration corresponding to an acoustic signal in a first frequency band included in data of a musical piece, loudspeaker **201** reproduces an acoustic signal in a frequency band excluding the first frequency band included in the data of the musical piece, and the first frequency band may be a band including a resonance frequency of actuator **203**.

(41) Next, details of loudspeaker system **200** will be described by using FIG. **2**A to FIG. **2**D.

(42) FIG. **2**A to FIG. **2**D are a front view and a cross-sectional view illustrating an example of loudspeaker system **200** according to Embodiment 1. In each of the drawings, (a) is a front view of loudspeaker system **200**, and (b) is a cross-sectional view of loudspeaker system **200**. Note that in (b) of each of the drawings, detailed illustration of a cross-section of loudspeaker **201** and actuator **203** is omitted.

(43) Actuator **203** is provided in loudspeaker box **202** so as to cause baffle panel **202***a* of loudspeaker box **202** to generate vibration, and is fixed to a surface in loudspeaker box **202** on an opposite side to baffle panel **202***a*, for example, as illustrated in FIG. **2**A to FIG. **2**D. Furthermore, loudspeaker **201** is fixed by being fitted in a hole provided on baffle panel **202***a* of loudspeaker box **202**. In this way, loudspeaker **201** and actuator **203** are integrated by loudspeaker box **202**.

(44) For example, a diameter of loudspeaker is 120 mm to 160 mm, and a diameter of actuator **203** is 70 mm to 80 mm. A distance from a center of loudspeaker **201** to a center of actuator **203** when viewing loudspeaker system **200** from a front is, for example, 120 mm to 150 mm. Since loudspeaker **201** and actuator **203** are integrated, the distance between loudspeaker **201** and actuator **203** can be shortened.

(45) When loudspeaker **201** and actuator **203** are separately provided, the distance between loudspeaker **201** and actuator **203** tends to increase, so that a phase of sound outputted from loudspeaker **201** and a phase of vibration by actuator **203** tend to deviate from each other, and powerful sound and vibration sometimes cannot be provided to a person seated on seat **100**. In regard with this, according to loudspeaker system **200** and seat **100** according to Embodiment 1, loudspeaker **201** and actuator **203** are integrated by one loudspeaker box **202**, so that the distance between loudspeaker **201** and actuator **203** can be shortened, and the phase of sound outputted from loudspeaker **201** and the phase of vibration by actuator **203** easily match to each other. Accordingly, it is possible to provide powerful sound and vibration to the person seated on seat **100**.

(46) FIG. **3** is a graph illustrating an example of frequency response of sounds (sound pressure) outputted from loudspeaker **201** and actuator **203** included in loudspeaker system **200** according to

Embodiment 1. FIG. **3** illustrates frequency responses of sounds outputted from loudspeaker **201** and sounds (vibration) outputted from actuator **203** that are measured at a distance of 50 cm from a front surface of loudspeaker system **200**.

(47) As illustrated in FIG. **3**, it can be seen that there is a corresponding relationship between loudspeaker **201** and actuator **203** in the way of change of a sound pressure level with respect to the frequency, and phases of sounds (vibration) outputted from them are roughly aligned with each other.

(48) For example, as illustrated in FIG. **2**B, loudspeaker box **202** may have partition **204** that separates actuator **203** and loudspeaker **201** in loudspeaker box **202**. Since actuator **203** and loudspeaker **201** can be separated by partition **204**, it is possible to make it difficult for loudspeaker **201** to be affected by the vibration by actuator **203**, and it is possible to make it difficult for actuator **203** to be affected by the vibration by loudspeaker **201**. For example, partition **204** may be formed of a same member as loudspeaker box **202**, or may be formed of a different member.

(49) For example, as illustrated in FIG. **2**C, loudspeaker box **202** may have sealed portion **205** that seals actuator **203** in loudspeaker box **202**. Since actuator **203** is sealed, it is possible to make it difficult for loudspeaker **201** to be affected by the vibration by actuator **203**, and it is possible to make it difficult for actuator **203** to be affected by the vibration by loudspeaker **201**. For example, sealed portion **205** may be formed of a same member as loudspeaker box **202**, or may be formed of a different member.

(50) For example, as illustrated in FIG. **2**D, a material of portion **206** of baffle panel **202***a* located between actuator **203** and loudspeaker **201** in a plan view of baffle panel **202***a* may be softer than a material of other portions of baffle panel **202***a*. Since vibration can be absorbed by portion **206** of the soft material of baffle panel **202***a*, it is possible to make it difficult for loudspeaker **201** to be affected by the vibration by actuator **203**, and it is possible to make it difficult for actuator **203** to be affected by the vibration by loudspeaker **201**. For example, the material of portion **206** is not particularly limited as long as the material is softer than the other portions (for example, loudspeaker box **202**) of baffle panel **202***a*.

(51) For example, loudspeaker box **202** may have two or more of partition **204**, sealed portion **205** and portion **206**.

Embodiment 2

(52) Next, a signal processing device according to Embodiment 2 will be described with reference to the drawings.

(53) FIG. **4** is a block diagram illustrating an example of signal processing device **10** according to Embodiment 2. Note that FIG. **4** also illustrates seat **100** besides signal processing device **10**.

(54) Signal processing device **10** is a device for reproducing a musical piece from one or more loudspeakers and one or more actuators that are provided in seat **100**. Signal processing device **10** includes obtainer **20** and outputter **30**. Signal processing device **10** includes a processor, a memory, and so on. The memory is a ROM (Read Only Memory) and a RAM (Random Access Memory) or the like and can store a program that is executed by a processor. Obtainer **20** and outputter **30** are realized by a processor or the like that executes a program stored in the memory.

(55) Obtainer **20** obtains data of a plurality of tracks forming a musical piece. For example, obtainer **20** obtains data of a plurality of tracks by obtaining data of a musical piece that is mixed-down from a music source such as CD (Compact Disc) and extracting data of a plurality of tracks from the obtained data of the musical piece. Note that obtainer **20** may obtain data of a plurality of tracks prepared in advance. The plurality of tracks are a plurality of tracks that are reproduced simultaneously in parallel. The data of the plurality of tracks include, for example, data of a track of a vocal, data of a track of a bass, data of a track of a drum, data of a track of a guitar, data of a track of a keyboard, and so on.

(56) Furthermore, for example, obtainer **20** may obtain an ultrasonic signal. Though not illustrated, for example, signal processing device **10** may include an ultrasonic generator, and obtainer **20** may

obtain an ultrasonic signal generated in the ultrasonic generator. For example, the ultrasonic generator has a pitch controller and an extractor.

(57) For example, the pitch controller controls a pitch (sound height) of data of a musical piece by n (n is a real number greater than 1) times. As the pitch of the data of the musical piece is multiplied by n, overall frequency components of the data of the musical piece shift to an n-fold higher frequency side. A value of n is not particularly limited, and is set at a value in which frequency components of 20 kHz or higher are included in sound source data the pitch of which is controlled. For example, the pitch controller obtains a maximum frequency component included in the data of the musical piece, and when the maximum frequency component is smaller than 20 kHz, the pitch controller may set n at a value larger than or equal to a value obtained by dividing 20 kHz by the maximum frequency component. For example, n may be 2 raised to the m (m is an integer larger than or equal to 1) power. That is to say, the pitch controller controls the pitch of the data of the musical piece to 2 raised to the m power (twice, four times, eight times, . . . and so on). Note that people can obtain an improvement effect on their mental and physical conditions by being exposed to ultrasonic waves, but the degree of the improvement effect on their mental and physical conditions obtained by ultrasonic waves may differ depending on the value of m. Thus, the ultrasonic generator may include an input unit that receives information indicating the degree of improvement effect on mental and physical conditions which the user desires to obtain, and the pitch controller may control the value of m according to information received by the input unit. Accordingly, the user can obtain the improvement effect of the degree desired by the user.

(58) Note that the pitch controller may control a sound pressure level in addition to the pitch. At this time, the pitch controller may increase the sound pressure level, or decrease the sound pressure level.

(59) The extractor extracts frequency components higher than or equal to 20 kHz that are included in the data of the musical piece the pitch of which is controlled. The extractor is, for example, a high pass filter. The extractor is realized, for example, by a digital filter, but may be realized by an analogue filter.

(60) Note that the extractor extracts frequency components of frequencies higher than or equal to a specific frequency (for example, 4 kHz or the like) that are included in the data of the musical piece first, and subsequently, the pitch controller may multiply the extracted frequency components by n (for example, by 10 times or the like). In this way, the frequency components of 20 kHz or higher can also be extracted.

(61) In this manner, the ultrasonic generator generates ultrasonic signals (acoustic signals including the frequency components of 20 kHz or higher), and obtainer **20** may obtain ultrasonic signals from the ultrasonic generator.

(62) Outputter **30** outputs an acoustic signal included in data of one track among the data of a plurality of tracks to one or more actuators, and outputs an acoustic signal included in data of another track among the data of the plurality of tracks to any loudspeaker of the one or more loudspeakers.

(63) Depending on the acoustic signal included in the data of the plurality of tracks forming the musical piece, uncomfortable vibration may be given to a person seated on seat **100** when the acoustic signal is outputted to the actuator. For example, when an acoustic signal included in a track of a bass where continuous heavy bass sound is generated is outputted to the actuator, continuous vibration is generated and uncomfortable vibration may be given to the person seated on seat **100**. In regard to this, according to signal processing device **10** according to Embodiment 2, an acoustic signal included in data of a specific track can be outputted to the actuator, in other words, an acoustic signal included in data of a track that hardly gives uncomfortable vibration to the person seated on seat **100** can be outputted to the actuator. Accordingly, giving uncomfortable vibration to the person seated on seat **100** can be suppressed.

(64) For example, outputter **30** may output an acoustic signal of a kick drum that is included in data

of a track of a drum among the data of the plurality of tracks to one or more actuators. For example, outputter **30** has low pass filter **31**, extracts the acoustic signal of the kick drum by inputting the data of the track of the drum to low pass filter **31**, and outputs the acoustic signal to the one or more actuators. Low pass filter **31** is realized by a digital filter, for example, but may be realized by an analogue filter. Note that when data of a track of a kick drum exists, obtainer **20** may obtain the data of the track of the kick drum. In this case, outputter **30** need not have low pass filter **31**, and may output the data of the track of the kick drum to one or more actuators without a filter. Vibration of the kick drum is not continuous vibration by heavy bass sound of a stringed instrument, but crisp rhythmic vibration, and hardly gives uncomfortable vibration from the actuator to the person seated on seat **100**, so that giving uncomfortable vibration to the person seated on seat **100** can be suppressed.

(65) The one or more actuators include, for example, actuator **301** provided inside seat surface **120** of seat **100** at a position corresponding to thighs of a person on seat surface **102** when the person is seated on seat **100**, or actuator **203** provided inside seat back **110** of seat **100** at a position corresponding to a sacrum of the person in seat back **110**, as described above.

(66) For example, outputter **30** may output the acoustic signal of the kick drum included in the data of the track of the drum among data of a plurality of tracks to actuator **301**. Accordingly, it is possible to give powerful vibration by the kick drum to the thighs of the person seated on seat **100**.

(67) For example, outputter **30** may output the acoustic signal of the kick drum included in the data of the track of the drum among the data of a plurality of tracks to actuator **203**. Accordingly, it is possible to give powerful vibration by the kick drum to the sacrum of the person seated on seat **100**.

(68) Furthermore, for example, outputter **30** may output acoustic signals included in data of tracks other than the track of the drum among the data of a plurality of tracks to any loudspeaker of one or more loudspeakers.

(69) The one or more loudspeakers include loudspeaker **201** that is provided inside seat back **110** of seat **100** at a position corresponding to an abdominal region of a person in seat back **110** when the person is seated on seat **100**, loudspeaker **401** that is provided inside seat back **110** of seat **100** at a position corresponding to a back of a person in seat back **110**, loudspeaker **501** provided inside headrest **130** of seat **100**, or tweeter **600** attached to headrest **130**, for example, as described above.

(70) For example, outputter **30** may output an acoustic signal included in data of a track of a bass among the data of a plurality of tracks to loudspeaker **201**. For example, outputter **30** outputs an acoustic signal in a low rage included in the data of the track of the bass to loudspeaker **201**. Accordingly, it is possible to expose the abdominal region of the person seated on seat **100** to a sound wave of heavy bass sound of the bass, and it is possible to provide powerful sound with vibration. For example, outputter **30** has low pass filter **34**, extracts an acoustic signal in a low range of a bass by inputting the data of the track of the bass to low pass filter **34**, and outputs the acoustic signal to loudspeaker **201**. Low pass filter **34** is realized by a digital filter, for example, but may be realized by an analogue filter.

(71) For example, outputter **30** may output an acoustic signal of a snare included in the data of the track of the drum, an acoustic signal included in the data of the track of the bass, and an acoustic signal included in data of a track of a vocal to loudspeaker **401**, among the data of a plurality of tracks.

(72) For example, outputter **30** has mid pass filter **32**, extracts an acoustic signal of a snare by inputting the data of the track of the drum to mid pass filter **32**, and outputs the acoustic signal to loudspeaker **401**. Mid pass filter **32** is a filter having a higher passband than low pass filter **31**. Mid pass filter **32** is realized by, for example, a digital filter, but may be realized by an analogue filter. Note that when data of the track of the snare exists, obtainer **20** may obtain the data of the track of the snare, and in this case, outputter **30** need not have mid pass filter **32**, and may output the data of the track of the snare to loudspeaker **401** without a filter.

(73) For example, outputter **30** has mid pass filter **35**, extracts an acoustic signal in a midrange of a bass by inputting the data of the track of the bass to mid pass filter **35**, and outputs the acoustic signal to loudspeaker **401**. Mid pass filter **35** is a filter having a higher passband than low pass filter **34**. Mid pass filter **35** is realized by, for example, a digital filter, but may be realized by an analogue filter.
(74) For example, outputter **30** has adder **36**, and inputs an acoustic signal of a snare, an acoustic signal in a midrange of a bass, and an acoustic signal of a vocal to adder **36**. Accordingly, outputter **30** can add the acoustic signal of the snare, the acoustic signal in the midrange of the bass, and the acoustic signal of the vocal, and can output the added acoustic signals to loudspeaker **401**.
(75) Accordingly, it is possible to output sounds of the snare, bass, and vocal from the position corresponding to the back of the person seated on seat **100**.
(76) For example, outputter **30** may output acoustic signals included in data of tracks except for the bass and drum among the data of a plurality of tracks, and an acoustic signal of a hi-hat included in the data of the track of the drum to loudspeaker **501** or tweeter **600**.
(77) For example, outputter **30** has high pass filter **33**, extracts an acoustic signal of a hi-hat by inputting the data of the track of the drum to high pass filter **33**, and outputs the acoustic signal to loudspeaker **501** and tweeter **600**. High pass filter **33** is a filter having a higher passband than mid pass filter **32**. High pass filter **33** is realized by, for example, a digital filter, but may be realized by an analogue filter. Note that when data of a track of a hi-hat exists, obtainer **20** may obtain the data of the track of the hi-hat, and in this case, outputter **30** need not have high pass filter **33**, and may output the data of the track of the hi-hat to loudspeaker **501** and tweeter **600** without a filter.
(78) For example, outputter **30** has adder/subtractor **37**. For example, outputter **30** inputs acoustic signals included in data of total tracks including all of the data of the track of the vocal, data of the track of the bass, data of the track of the drum, data of the track of the guitar, data of the track of the keyboard, and so on, and an acoustic signal of the hi-hat to a plus terminal of adder/subtractor **37**. Furthermore, for example, outputter **30** inputs an acoustic signal included in the data of the track of the drum, and an acoustic signal included in the data of the track of the bass to a minus terminal of adder/subtractor **37**. Accordingly, outputter **30** can subtract the acoustic signal included in the data of the track of the drum and the acoustic signal included in the data of the track of the bass from the acoustic signals included in the data of the total tracks, and add the acoustic signals and an acoustic signal of the hi-hat. In other words, it is possible to output signals obtained by adding up the acoustic signals included in the data of the tracks except for the tracks of the bass and drum among the data of the plurality of tracks, and the acoustic signal of the hi-hat included in the data of the track of the drum to loudspeaker **501** and tweeter **600**.
(79) Accordingly, it is possible to output sounds (for example, sounds of the vocal, guitar, keyboard and so on) other than sounds of the bass and drum, and the sound of the hi-hat from headrest **130**.
(80) For example, outputter **30** may further output ultrasonic signals to loudspeaker **501** or tweeter **600**. For example, outputter **30** has adder **38**, and as described above, when obtainer **20** obtains an ultrasonic signal, outputter **30** inputs acoustic signals included in the data of the total tracks, and the ultrasonic signal to adder **38**. Accordingly, it is possible to add up the acoustic signals included in the data of the total tracks and the ultrasonic signal, and it is possible to output the acoustic signals to which the ultrasonic signal is added to loudspeaker **501** or tweeter **600**.
(81) Accordingly, it is possible to expose the head of a person seated on seat **100** to ultrasonic waves, and it is possible to give a hypersonic effect onto the person seated on seat **100**. Specifically, it is possible to give an effect of improving cerebral blood flow and improving mental and physical conditions to the person seated on seat **100**.

Embodiment 3

(82) Next, the signal processing device according to Embodiment 3 will be described with reference to the drawings.
(83) FIG. **5** is a block diagram illustrating an example of signal processing device **40** according to

Embodiment 3. Note that FIG. **5** also illustrates seat **100** besides signal processing device **40**.
(84) Signal processing device **40** is a device for reproducing a musical piece from one or more loudspeakers and one or more actuators that are provided in seat **100**. Signal processing device **40** includes obtainer **50** and outputter **60**. Signal processing device **40** includes a processor, a memory and so on. The memory is a ROM and a RAM or the like, and can store a program that is executed by the processor. Obtainer **50** and outputter **60** are realized by the processor or the like that executes a program stored in the memory.
(85) Obtainer **50** obtains data of a musical piece. Specifically, obtainer **50** obtains the data of a musical piece that is mixed down from a music source such as a CD.
(86) Furthermore, for example, obtainer **50** may obtain an ultrasonic signal. For example, signal processing device **40** may include an ultrasonic generator as in signal processing device **10**, and obtainer **50** may obtain an ultrasonic signal generated in the ultrasonic generator. Details of the ultrasonic generator are the same as that described in Embodiment 2 and therefore, explanation will be omitted.
(87) Outputter **60** outputs an acoustic signal in a first frequency band included in data of a musical piece to the one or more actuators, and outputs an acoustic signal in a frequency band except for the first frequency band included in the data of the musical piece to the one or more loudspeakers. The first frequency band is a band including a resonance frequency of the one or more actuators. For example, outputter **60** outputs the acoustic signal in the first frequency band to the one or more actuators and outputs the acoustic signal in the frequency band except for the first frequency band to the one or more loudspeakers, by applying filtering processing to the data of the musical piece. For example, the one or more actuators include actuator **203** or **301**, and the one or more loudspeakers include loudspeaker **201**.
(88) When the system described in Japanese Unexamined Patent Application Publication No. 2007-181135 or the like is applied to a seat in which actuators and loudspeakers are provided, signals in the same frequency band are inputted to the actuator and the loudspeaker, and thus uncomfortable vibration can be given to the person seated on the seat. In regard to this, in Embodiment 3, frequency bands of signals that are outputted to actuator **203** or **301**, and loudspeaker **201** are different, and thus it is possible to expose optimal spots of the person seated on seat **100** to vibration and heavy bass sound from actuator **203** or **301**, and loudspeaker **201** respectively, and giving uncomfortable vibration to the person seated on seat **100** can be suppressed.
(89) For example, vibration of a kick drum is not continuous vibration by heavy bass sound of a stringed instrument, but is crisp rhythmic vibration, and hardly gives uncomfortable vibration to the person seated on seat **100**. Furthermore, a vibration frequency of the rhythmic vibration like this is a frequency close to a resonance frequency of actuator **203** or **301**. Thus, giving uncomfortable vibration to the person seated on seat **100** can be suppressed by outputting, to actuator **203** or **301**, an acoustic signal in the first frequency band including the resonance frequency of actuator **203** or **301**, specifically, an acoustic signal of rhythmic vibration with the vibration frequency close to the resonance frequency of actuator **203** or **301**. For example, it is possible to give powerful vibration by actuator **203** or **301** to the thighs or the sacrum of the person seated on seat **100**. Furthermore, when heavy bass sound is outputted from loudspeaker **201**, it is possible to expose the abdominal region of the person seated on seat **100** to sound waves of the heavy bass sound, and it is possible to provide powerful sound with vibration.
(90) For example, outputter **60** has low pass filters **61** and **62**. For example, outputter **60** extracts an acoustic signal in the first frequency band included in the data of a musical piece, by inputting the data of the musical piece to low pass filter **61**, and outputs the acoustic signal to actuators **203** and **301**. Furthermore, for example, outputter **60** extracts an acoustic signal in a frequency band except for the first frequency band included in the data of the musical piece, by inputting the data of the musical piece to low pass filter **62**, and outputs the acoustic signal to loudspeaker **201**. Low pass filters **61** and **62** are realized by digital filters, for example, but may be realized by analogue filters.

(91) FIG. **6** is a view illustrating an example of filter characteristics of low pass filters **61** and **62** included in outputter **60** according to Embodiment 3. In FIG. **6**, (a) illustrates filter characteristics of low pass filter **61**, and (b) in FIG. **6** illustrates filter characteristics of low pass filter **62**.
(92) As illustrated in (a) in FIG. **6**, low pass filter **61** is, for example, a band pass filter with a high Q value, and has a band including the resonance frequency (for example, 90 Hz) of actuators **203** and **301** as a passband. Accordingly, it is possible to output acoustic signals in the first frequency band (band including 90 Hz, for example) included in the data of the musical piece to actuators **203** and **301**, and actuators **203** and **301** can generate rhythmic vibration of a kick drum or the like.
(93) On the other hand, as illustrated in (b) in FIG. **6**, low pass filter **62** is, for example, a band elimination filter, and has the first frequency band as a stopband. Since the acoustic signals in the first frequency band including the resonance frequency of actuators **203** and **301** are attenuated by low pass filter **62**, it is possible to suppress amplitude interference of acoustic signals in the frequency band except for the first frequency band and the acoustic signals in the first frequency band.
(94) For example, outputter **60** may have mid pass filter **63**. Mid pass filter **63** is a filter having a higher passband than low pass filter **61**. For example, outputter **60** extracts acoustic signals in a midrange (for example, 150 Hz to 800 Hz) included in data of a musical piece, by inputting the data of the musical piece in mid pass filter **63**, and outputs the acoustic signals to loudspeaker **401**. Mid pass filter **63** is realized by, for example, a digital filter, but may be realized by an analogue filter. Accordingly, it is possible to output sound of a snare, bass, vocal and so on from a position corresponding to the back of the person seated on seat **100**.
(95) For example, outputter **60** may have mid-high pass filter **64**. Mid-high pass filter **64** is a filter having a higher passband than mid pass filter **63**. For example, outputter **60** extracts acoustic signals in a mid-high range (for example, 350 Hz to 100 kHz) included in the data of a musical piece, by inputting the data of the musical piece to the mid-high pass filter **64**, and outputs the acoustic signals to loudspeaker **501** or tweeter **600**. Mid pass filter **63** and mid-high pass filter **64** are realized by, for example, digital filters, but may be realized by analogue filters. Accordingly, it is possible to output sounds of a guitar, keyboard, vocal, hi-hat and so on from headrest **130**.
(96) For example, outputter **60** may further output ultrasonic signals to loudspeaker **501** or tweeter **600**. For example, outputter **60** has adder **65**, and when obtainer **50** obtains an ultrasonic signal, outputter **60** inputs the data of a musical piece and the ultrasonic signal to adder **65**, as described above. Accordingly, it is possible to add up the data of the musical piece and the ultrasonic signal, and it is possible to output an acoustic signal including the ultrasonic signal extracted from the data of the musical piece to which the ultrasonic signal is added to loudspeaker **501** or tweeter **600**.
(97) Accordingly, it is possible to expose the head of the person seated on seat **100** to an ultrasonic wave, and it is possible to give a hypersonic effect to the person seated on seat **100**. Specifically, it is possible to give an effect of improving cerebral blood flow and improving mental and physical conditions to the person seated on seat **100**.

OTHER EMBODIMENTS

(98) Exemplary embodiments have been described above as examples of the techniques according to the present disclosure. The techniques according to the present disclosure are not limited to the foregoing exemplary embodiments, and are also applicable to embodiments obtained by making changes, substitutions, additions, omissions, or the like, as appropriate. For example, variations such as those described below are included in one embodiment of the present disclosure.
(99) For example, in Embodiment 1 described above, the example in which seat **100** includes loudspeaker systems **200**, **400**, and **500**, and actuator system **300** is described, but seat **100** can include at least loudspeaker system **200**.
(100) For example, in Embodiment 1 described above, the example in which loudspeaker system **200** is provided inside seat back **110** of seat **100** at the position that is below the center in seat back **110** is described, but loudspeaker system **200** may be provided inside seat back **110** of seat **100** at a

position that is above the center of seat back **110**, or may be provided inside seat surface **120**.
(101) For example, in each of Embodiments 2 and 3 described above, the example in which seat **100** includes actuators **203** and **301**, loudspeakers **201**, **401**, and **501**, and tweeter **600** is described, but the present disclosure is not limited to the example. For example, seat **100** can include at least one actuator of actuators **203** and **301**, and can include at least one loudspeaker of loudspeakers **201**, **401**, and **501**, and tweeter **600**.
(102) For example, in each of Embodiments 2 and 3 described above, the example in which ultrasonic signals are outputted from loudspeaker **501** or tweeter **600** is described, but ultrasonic signals need not be outputted from loudspeaker **501** or tweeter **600**.
(103) For example, in each of Embodiments 1 to 3 described above, the example in which seat **100** includes headrest **130** is described, but seat **100** need not include headrest **130**.
(104) Aside from these, the present disclosure includes forms obtained by making various modifications to the foregoing embodiments that can be conceived by those skilled in the art, as well as forms realized by arbitrarily combining structural components and functions in the respective embodiments, without departing from the essence of the present disclosure.
Supplementary Remarks
(105) The disclosures in the foregoing embodiments disclose the techniques described below.
(106) (Technique 1) A loudspeaker system comprising: a loudspeaker; a loudspeaker box provided inside a seat, and in which the loudspeaker is provided; and an actuator, wherein the actuator is provided inside the loudspeaker box to cause a baffle panel of the loudspeaker box to generate vibration.
(107) When the loudspeaker and the actuator are separately provided, the distance between the loudspeaker and the actuator tends to increase, so that a phase of sound outputted from the loudspeaker and a phase of vibration by the actuator tend to deviate from each other, and powerful sound and vibration sometimes cannot be provided to a person seated on the seat. In regard with this, in the present disclosure, the loudspeaker and the actuator are integrated by one loudspeaker box, so that the distance between the loudspeaker and the actuator can be shortened, and the phase of sound outputted from the loudspeaker and the phase of vibration by the actuator easily match to each other. Accordingly, it is possible to provide powerful sound and vibration to the person seated on the seat.
(108) (Technique 2) The loudspeaker system according to Technique 1, wherein the loudspeaker box is provided inside a seat back of the seat, at a position that is below a center of the seat back.
(109) Accordingly, it is possible to give powerful vibration by the actuator to an area around the abdominal region and buttocks of the person seated on the seat. Furthermore, when heavy bass sound is outputted from the loudspeaker, it is possible to expose the area around the abdominal region and buttocks of the person seated on the seat to a sound wave of heavy bass sound from the loudspeaker, and thus it is possible to provide powerful sound with vibration.
(110) (Technique 3) The loudspeaker system according to Technique 2, wherein the actuator is provided lower in the seat back than the loudspeaker is.
(111) Accordingly, it is possible to give powerful vibration by the actuator to an area around the buttocks of the person seated on the seat.
(112) (Technique 4) The loudspeaker system according to Technique 3, wherein the loudspeaker is provided in the seat back, at a position corresponding to an abdominal region of a person when the person is seated on the seat, and the actuator is provided in the seat back, at a position corresponding to a sacrum of the person when the person is seated on the seat.
(113) Accordingly, it is possible to give powerful vibration by the actuator to the sacrum of the person seated on the seat. Furthermore, when heavy bass sound is outputted from the loudspeaker, it is possible to expose the abdominal region of the person seated on the seat to sound waves of the heavy bass sound, and thus it is possible to provide powerful sound with vibration.
(114) (Technique 5) The loudspeaker system according to any one of Techniques 1 to 4, wherein

the loudspeaker box includes a partition that separates the actuator and the loudspeaker inside the loudspeaker box.
(115) Since the actuator and the loudspeaker can be separated by the partition, it is possible to make it difficult for the loudspeaker to be affected by the vibration by the actuator, and it is possible to make it difficult for the actuator to be affected by the vibration the by loudspeaker.
(116) (Technique 6) The loudspeaker system according to any one of Techniques 1 to 5, wherein the loudspeaker box includes a sealed portion that seals in the actuator inside the loudspeaker box.
(117) Since the actuator is sealed in, it is possible to make it difficult for the loudspeaker to be affected by the vibration by the actuator, and it is possible to make it difficult for the actuator to be affected by the vibration the by loudspeaker.
(118) (Technique 7) The loudspeaker system according to any one of Techniques 1 to 6, wherein a material of a portion of the baffle panel which is located between the actuator and the loudspeaker in a plan view of the baffle panel is softer than a material of other portions of the baffle panel.
(119) Since vibration can be absorbed by the portion of the soft material of the baffle panel, it is possible to make it difficult for loudspeaker **201** to be affected by the vibration by the actuator, and it is possible to make it difficult for the actuator to be affected by the vibration by the loudspeaker.
(120) (Technique 8) The loudspeaker system according to any one of Techniques 1 to 7, wherein the actuator generates vibration according to an acoustic signal included in data of a track among data of a plurality of tracks constituting a musical piece, and the loudspeaker reproduces an acoustic signal included in data of an other track among the data of the plurality of tracks.
(121) Depending on the acoustic signal included in the data of the plurality of tracks forming the musical piece, uncomfortable vibration may be given to the person seated on the seat when the acoustic signal is outputted to the actuator. For example, when an acoustic signal included in a track of a bass where continuous heavy bass sound is generated is outputted to the actuator, continuous vibration is generated and uncomfortable vibration may be given to the person seated on the seat. In regard to this, in the present disclosure, an acoustic signal included in data of a specific track can be outputted to the actuator, in other words, an acoustic signal included in data of a track that hardly gives uncomfortable vibration to the person seated on the seat can be outputted to the actuator. Accordingly, giving uncomfortable vibration to the person seated on the seat can be suppressed.
(122) (Technique 9) The loudspeaker system according to Technique 8, wherein the actuator generates the vibration according to an acoustic signal of a kick drum included in data of a drum track among the data of the plurality of tracks, and the loudspeaker reproduces an acoustic signal included in data of a track other than the drum track among the data of the plurality of tracks.
(123) The vibration of a kick drum is not continuous vibration by heavy bass sound of a stringed instrument, but is crisp rhythmic vibration, and hardly gives uncomfortable vibration from the actuator to the person seated on the seat, and thus giving uncomfortable vibration to the person seated on the seat can be suppressed.
(124) (Technique 10) The loudspeaker system according to any one of Techniques 1 to 7, wherein the actuator generates vibration according to an acoustic signal of a first frequency band included in data of a musical piece, the loudspeaker reproduces an acoustic signal of a frequency band excluding the first frequency band, the frequency band being included in the data of the musical piece, and the first frequency band is a band that includes a vibration frequency of the actuator.
(125) The vibration of a kick drum is not continuous vibration by heavy bass sound of a stringed instrument, but is crisp rhythmic vibration, and hardly gives uncomfortable vibration to the person seated on the seat. Furthermore, a vibration frequency of a rhythmic vibration like this is a frequency close to a vibration frequency of the actuator. Thus, giving uncomfortable vibration to the person seated on the seat can be suppressed by outputting, to the actuator, an acoustic signal in the first frequency band including the vibration frequency of the actuator, specifically, an acoustic signal of rhythmic vibration with the vibration frequency close to the vibration frequency of the

actuator.
(126) (Technique 11) A seat comprising: the loudspeaker system according to any one of Techniques 1 to 10.
(127) Accordingly, it is possible to provide a seat capable of providing powerful sound and vibration to the person seated on the seat.
(128) While various embodiments have been described herein above, it is to be appreciated that various changes in form and detail may be made without departing from the spirit and scope of the present disclosure as presently or hereafter claimed.
Further Information about Technical Background to this Application
(129) The disclosure of the following patent application including specification, drawings, and claims is incorporated herein by reference in its entirety: Japanese Patent Application No. 2022-155130 filed on Sep. 28, 2022.
INDUSTRIAL APPLICABILITY
(130) The present disclosure can be applied to a seat, and the like, in which a loudspeaker and an actuator are provided inside the seat, and which is capable of reproducing a musical piece.

Claims

1. A loudspeaker system comprising: a loudspeaker; a loudspeaker box provided inside a seat, and in which the loudspeaker is provided; and an actuator, wherein the actuator is provided inside the loudspeaker box to cause a baffle panel of the loudspeaker box to generate vibration.
2. The loudspeaker system according to claim 1, wherein the loudspeaker box is provided inside a seat back of the seat, at a position that is below a center of the seat back.
3. The loudspeaker system according to claim 2, wherein the actuator is provided lower in the seat back than the loudspeaker is.
4. The loudspeaker system according to claim 3, wherein the loudspeaker is provided in the seat back, at a position corresponding to an abdominal region of a person when the person is seated on the seat, and the actuator is provided in the seat back, at a position corresponding to a sacrum of the person when the person is seated on the seat.
5. The loudspeaker system according to claim 1, wherein the loudspeaker box includes a partition that separates the actuator and the loudspeaker inside the loudspeaker box.
6. The loudspeaker system according to claim 1, wherein the loudspeaker box includes a sealed portion that seals in the actuator inside the loudspeaker box.
7. The loudspeaker system according to claim 1, wherein a material of a portion of the baffle panel which is located between the actuator and the loudspeaker in a plan view of the baffle panel is softer than a material of other portions of the baffle panel.
8. The loudspeaker system according to claim 1, wherein the actuator generates vibration according to an acoustic signal included in data of a track among data of a plurality of tracks constituting a musical piece, and the loudspeaker reproduces an acoustic signal included in data of an other track among the data of the plurality of tracks.
9. The loudspeaker system according to claim 8, wherein the actuator generates the vibration according to an acoustic signal of a kick drum included in data of a drum track among the data of the plurality of tracks, and the loudspeaker reproduces an acoustic signal included in data of a track other than the drum track among the data of the plurality of tracks.
10. The loudspeaker system according to claim 1, wherein the actuator generates vibration according to an acoustic signal of a first frequency band included in data of a musical piece, the loudspeaker reproduces an acoustic signal of a frequency band excluding the first frequency band, the frequency band being included in the data of the musical piece, and the first frequency band is a

band that includes a vibration frequency of the actuator.

11. A seat comprising: the loudspeaker system according to claim 1.