United States Patent	12392150
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Yamaguchi; Masao

Booth

Abstract

A booth includes one or more wall plates surrounding an internal space, a ceiling plate connected to the plates and above the space, and a communication portion connected to either the ceiling plate or an upper part of a wall plate and through which air flows. The communication portion includes area portions arranged along an air flow direction and each having an opening through which the air flows, the area portions including first, second, and third portions in this order from the outside of the booth towards the internal space, and a first area of the opening of the first portion along a surface perpendicular to the air flow direction is smaller than a second area of the opening of the second portion along the surface, and a third area of the opening of the third portion along the surface is smaller than the second area.

Inventors:	**Yamaguchi; Masao (Tokyo, JP)**
Applicant:	**TOSHIBA TEC KABUSHIKI KAISHA** (Tokyo, JP)
Family ID:	**1000008764381**
Assignee:	**Toshiba Tec Kabushiki Kaisha (Tokyo, JP)**
Appl. No.:	**17/944161**
Filed:	**September 13, 2022**

Prior Publication Data

Document Identifier	Publication Date
US 20230175276 A1	Jun. 08, 2023

Foreign Application Priority Data

JP	2021-197080	Dec. 03, 2021

Publication Classification

Int. Cl.: **E04H1/12** (20060101); **G10K11/02** (20060101)

U.S. Cl.:

CPC   **E04H1/125** (20130101); **G10K11/02** (20130101);

Field of Classification Search

CPC: E04H (1/125); E04H (1/12); G10K (11/02); Y02A (40/25); E04B (1/99); F01N (1/08); F01N (1/089)

USPC: 181/249; 181/255; 181/270; 181/272

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
1903983	12/1932	De Bothezat	454/341	F24F 7/007
2875678	12/1958	Shepherd	454/355	F24F 7/025
2987983	12/1960	Solzman	415/212.1	F24F 7/025
3110357	12/1962	Jenn	454/262	F24F 7/025
3158457	12/1963	Whitfield	454/231	F24F 3/167
3302547	12/1966	Wasserman	52/236.1	F24F 7/025
3611907	12/1970	Wasserman	D25/16	E04B 1/8218
4120376	12/1977	Palmer	181/204	E04H 1/1238
5123874	12/1991	White, III	181/290	E04B 1/34321
8650833	12/2013	Polston	52/95	F24F 7/02
10624232	12/2019	Krietzman	N/A	F24F 7/04
11212928	12/2020	Lewis, II	N/A	H05K 5/0213
11259446	12/2021	Lewis, II	N/A	H05K 7/20754
11549703	12/2022	Haveri	N/A	F24F 7/06
2018/0257098	12/2017	Pihlblad	N/A	B05B 16/60
2020/0018060	12/2019	Watanabe	N/A	E04B 1/34326
2023/0029778	12/2022	Yong	N/A	E04B 1/8218
2023/0175276	12/2022	Yamaguchi	52/39	G10K 11/02

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2002-266443	12/2001	JP	N/A
2005-076405	12/2004	JP	N/A
2020-066858	12/2019	JP	N/A
2020-133357	12/2019	JP	N/A
2020-139300	12/2019	JP	N/A

Primary Examiner: Glessner; Brian E

Assistant Examiner: Barlow; Adam G

Attorney, Agent or Firm: Kim & Stewart LLP

Background/Summary

FIELD
(2) Embodiments described herein relate generally to booths.
BACKGROUND
(3) A booth having a box-shaped body to provide a personal space is used by an individual such as a worker, a student, or the like.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a schematic cross-sectional view of a booth according to a first embodiment.
(2) FIG. **2** is a diagram showing a measurement device for measuring the sound absorption and sound insulation effects by a wall plate of a booth according to a first embodiment.
(3) FIG. **3** is a table showing the difference in sound pressure level of sound absorption and sound insulation with and without a wall board using the measurement device shown in FIG. **2**.
(4) FIG. **4** is a schematic cross-sectional view illustrating a communication portion and an area changing portion of a booth indicated by region IV in FIG. **1**.
(5) FIG. **5** is a schematic cross-sectional view showing a cylindrical body which is a part of the area changing portion of the booth shown in FIG. **4**.
(6) FIG. **6** is a diagram illustrating the relationship between the frequency of a male voice and a female voice and sound pressure level.
(7) FIG. **7** is a graph showing an attenuation amount of sound within a predetermined frequency range in a state of condition **1** of the cylindrical body shown in FIG. **5**.
(8) FIG. **8** is a graph showing an attenuation amount of sound within a predetermined frequency range in a state of condition **2** of the cylindrical body shown in FIG. **5**.
(9) FIG. **9** is a graph showing an attenuation amount of sound within a predetermined frequency range in a state of condition **3** of the cylindrical body shown in FIG. **5**.
(10) FIG. **10** is a graph showing the amount of attenuation of sound within a predetermined frequency range when the amount of attenuation of sound shown in FIGS. **7** to **9** is added.
(11) FIG. **11** is a schematic cross-sectional view of a booth according to a comparative example.
(12) FIG. **12** is a schematic cross-sectional view showing a modified example of a cylindrical body which can be a part of an area changing portion of the booth shown in FIG. **4**.
(13) FIG. **13** is a schematic cross-sectional view illustrating another modified example of a cylindrical body that can be a part of an area changing portion of the booth illustrated in FIG. **4**.
(14) FIG. **14** is a schematic cross-sectional view showing still another modified example of a cylindrical body which can be a part of an area changing portion of the booth shown in FIG. **4**.
(15) FIG. **15** is a schematic cross-sectional view illustrating a communication portion and an area changing portion of a booth according to a first modified example of a first embodiment.
(16) FIG. **16** is a graph showing an attenuation amount of sound within a predetermined frequency range of the area changing portion shown in FIG. **15**.
(17) FIG. **17** is a schematic cross-sectional view illustrating a communication portion and an area changing portion of a booth according to a second modified example of a first embodiment.
(18) FIG. **18** is a schematic cross-sectional view illustrating a communication portion and an area

changing portion of a booth according to a third modified example of a first embodiment.

(19) FIG. **19** is a schematic cross-sectional view of a booth according to a second embodiment.

(20) FIG. **20** is a schematic cross-sectional view of a booth according to a third embodiment.

(21) FIG. **21** is a schematic cross-sectional view of a booth according to a fourth embodiment.

(22) FIG. **22** is a schematic cross-sectional view of a booth according to a fifth embodiment.

(23) FIG. **23** is an enlarged view of a position indicated by region XXIII in FIG. **22**.

DETAILED DESCRIPTION

(24) In general, according to one embodiment, a booth includes one or more wall plates surrounding an internal space, a ceiling plate connected to the wall plates and above the internal space, and a communication portion connected to either the ceiling plate or an upper part of one of the wall plates and through which air flows between the internal space and an outside of the booth. The communication portion includes a plurality of area portions arranged along an air flow direction and each having an opening through which the air flows. The area portions include at least first, second, and third portions in this order from the outside of the booth towards the internal space. A first area of the opening of the first portion along a surface perpendicular to the air flow direction is smaller than a second area of the opening of the second portion along the surface. A third area of the opening of the third portion along the surface is smaller than the second area.

(25) Hereinafter, certain example embodiments will be described with reference to the drawings. A booth described in this disclosure can be applied to various situations such as, for example, for use as a private room or privacy room. Such a booth can be fixed or installed at various positions such as the inside of an office building, a train station, or on a train. Such a booth or room can be used as a work booth in which a worker or the like works or a student or the like studies. Web conferences and the like can also be held inside the booth. In addition, the booth can be used as a private relaxation room in which a user takes a rest therein. Further, the booth can be used a dressing room used in conjunction with a shower room or as emergency equipment such as a simple toilet booth in the event of a disaster.

First Embodiment

(26) A booth **10** according to a first embodiment will be described with reference to FIGS. **1** to **11**.

(27) FIG. **1** shows a schematic cross-sectional view of the booth **10** according to the first embodiment. As shown in FIG. **1**, the booth **10** is formed in a box shape that is fixed to or otherwise placed on a floor F. When the booth **10** is installed or placed indoors, an upper end of the booth **10** has a height that does not reach an indoor ceiling.

(28) The booth **10** includes a box-shaped booth main body or housing **12** that is fixed to or placed on the floor F, a tubular communication portion **14** that is provided in the booth main body **12** and allows the inside and the outside of the booth main body **12** to communicate with each other, and an area changing portion **16** that is provided in the communication portion **14**.

(29) The booth main body **12** is formed in a box shape such as a substantially quadrangular prism shape. The booth main body **12** in other examples may be formed in a substantially polygonal columnar shape or a cylindrical columnar shape. It is preferable that there is no substantial gap between the booth main body **12** and the floor F.

(30) The booth main body **12** has an internal space having a size equal to or larger than a width, a depth, and a height of an expected user such as an adult person. The internal space is sized such that a typical user can enter into the booth main body **12**. For example, if the shape of the booth main body **12** is a substantially quadrangular prism shape then the interior volume is arranged to permit the user to be within the booth main body **12**. When the booth **10** is used as a work booth, for example, a desk and a chair may be accommodated in the booth main body **12** to provide a workspace or the like, and the booth main body **12** is sized such that the user can get into and out of the chair. In some examples, it may be preferable that the booth main body **12** has a size to permit a plurality of users to be accommodated therein at the same time.

(31) It is generally preferable that the booth main body **12** has a door **18** through which a user

enters and leaves the booth **10**.

(32) In an example where the booth **10** is light enough to be easily lifted by a user, for example, when the booth **10** is made of cardboard, the door **18** may not be necessary. If the booth **10** is light enough to allow the user to easily lift the booth **10**, then the user can simply place the booth **10** at a desired position so as to surround a desk and a chair placed on the floor F.

(33) Here, the booth main body **12** has a wall plate **121** that separates the inside and the outside of the booth main body **12**. The wall plate **121** is used as, for example, an outer wall and a partition wall. The wall plate **121** may have a double-layer structure or a multiple-layer structure. In such a case, the wall plate **121** includes an outer wall place that works as an outer wall, and an inner wall plate that works as a partition wall.

(34) Various measurement methods exist for measuring the properties of the wallboard **121**. Here, the sound insulation properties of the wall plate **121** were measured using, for example, a noise meter **22** and a speaker **24** as shown in FIG. **2**. In addition, FIG. **3** shows the difference in sound pressure level with and without the wall plate **121** using the noise meter **22** and the speaker **24** shown in FIG. **2**.

(35) As shown in FIG. **2**, the microphone of the noise meter **22** was installed at a height of 120 cm from the floor surface F and at a distance of 30 cm away from the wall plate **121**. The speaker **24** was installed at a height of 120 cm from the floor surface F and at a distance of 80 cm away from the wall plate **121**. The microphone and the speaker **24** of the noise meter **22** face each other with a distance corresponding to 110 cm and the thickness of the wall plate **121**.

(36) The male voice emitted from the speaker **24** shown in FIG. **2** has the same content, the same loudness, and the same frequency range regardless of the presence or absence of the wall plate **121**, and is within a frequency range corresponding to a human voice in daily (normal) conversation. Similarly, a female voice is a voice having the same content, the same loudness, and the same frequency range regardless of the presence or absence of the wall plate **121**, and is similarly in a frequency range corresponding to a human voice in daily (normal) conversation.

(37) As shown in FIG. **3**, a difference in sound pressure level measured by the sound level meter **22** occurred depending on the presence/absence of the wall plate **121**. In the case of "presence" where the wall plate **121** is present, the sound pressure level is lower than that in the case of "absence" where the wall plate **121** is not present. Since the sound pressure level difference exists, it can be seen that the wall plate **121** used in the booth main body **12** of the booth **10** provides sound absorption and sound insulation by the presence of the wall plate **121** for each of white noise, a male voice, and a female voice. That is, the booth **10** using the wall plate **121** absorbs or insulates sounds emitted outside the booth main body **12** by the wall plate **121**.

(38) As shown in FIG. **1**, the booth main body **12** is formed into a quadrangular cylindrical shape by four wall plates **121**, for example. These four wall plates **121** may be integrated with one another or may be separate bodies.

(39) In the present embodiment, the booth main body **12** has a ceiling portion **20** above the wall plate **121** of the booth main body **12**. The ceiling portion **20** is formed of, for example, a wall plate having the same material and the same thickness as the wall plate **121**. The ceiling portion **20** may be formed of a material different from that of the wall plate **121**.

(40) The ceiling portion **20** includes the communication portion **14**. The communication portion **14** is provided, for example, at the center of the ceiling portion **20**. It is also preferable that the communication portion **14** is provided at a position close to any of the four wall plates **121** of the booth main body **12** on the end side away from the center of the ceiling portion **20**.

(41) In the present embodiment, the communication portion **14** is formed in a tubular shape. The communication portion **14** of this example penetrates the ceiling portion **20** in the vertical direction. Thus, the communication portion **14** allows for communication between the inside and the outside of the booth main body **12**. The communication portion **14** is formed in a tubular shape having an appropriate shape such as a cylindrical shape or a polygonal tubular shape. A space

between the ceiling portion **20** and the communication portion **14** is sealed without a gap.

(42) As shown in FIG. **4** (depicting region IV of FIG. **1**), an area changing portion **16** is provided on the inner wall of the cylindrical communication portion **14** along a direction intersecting a certain surface (for example, a surface parallel to the floor F) to change the volume (space) inside the communication portion **14**, for example, in stepwise increments a plurality of times. The communication portion **14** and the area changing portion **16** are integrally formed of, for example, a wall plate material having the same thickness and composition as the wall plate **121**. The communication portion **14** and the area changing portion **16** may be formed of a material different from that of the wall plate **121**.

(43) The area changing portion **16** can be formed such that the spaces inside and the outside of the booth main body **12** are connected to one another in manner to permit a viewer to look from the inside to the outside of the booth main body **12** and vice versa. That is, the area changing portion **16** is formed such that one end thereof can be seen from the other end. Therefore, the inside or outside of the booth **10** can be seen from the outside or the inside through the area changing portion **16**.

(44) However, the area changing portion **16** attenuates the sound pressure of a sound that is input to one end of the area changing portion **16** along the flow direction of air and output from the other end. It is assumed that air flows generally from the outside to the inside of the booth main body **12** through the area changing portion **16**. In such a case, the area changing portion **16** includes: a first area portion **161** having an area SA, a second area portion **162** having an area SB larger than the area SA, a third area portion **163** having an area SC smaller than the area SB, a fourth area portion **164** having an area SD larger than the area SC, a fifth area portion **165** having an area SE smaller than the area SD, a sixth area portion **166** having an area SF larger than the area SE, and a seventh area portion **167** having an area SG smaller than the area SF, in order along the air flow direction. The first to seventh area portions **161** to **167** are disposed parallel to the floor F and arranged along the air flow direction.

(45) In the present embodiment, each of the first to seventh area portions **161** to **167** corresponds to a disk-shaped or cylindrical volume each sharing a common central axis C.

(46) In the area changing portion **16** of the present embodiment shown in FIGS. **1** and **4**, the air flow direction can be a direction from the upper side to the lower side and a direction from the lower side to the upper side. That is, the air flows from the outside of the booth **10** to the inside of the booth main body **12** through the communication portion **14**, and also flows from the inside of the booth main body **12** to the outside of the booth **10**. In the present embodiment, the seventh area portion **167** can be disposed in the ceiling portion **20**, and the first area portion **161** is disposed farthest away from the ceiling portion **20**.

(47) The area changing portion **16** includes, for example, a plurality of reflection surfaces **1711**, **1712**, and **1713** (also referred to as first reflection surfaces **1711**, **1712**, **1713**) that generate a reflected sound by which a part of a sound entering the booth main body **12** from the outside of the booth main body **12** through the area changing portion **16** is reflected back toward the outside of the area changing portion **16**. For this reason, a part of the sound traveling to enter the booth main body **12** through the area changing portion **16** is reduced by the reflection surfaces **1711**, **1712**, **1713**. For this reason, the reflected sound and the traveling sound may interfere with each other, and the sound pressure of the sound entering the inside of the booth main body **12** from the outside of the booth main body **12** is weakened.

(48) In addition, the area changing portion **16** includes, for example, a plurality of reflection surfaces **1721**, **1722**, and **1723** (also referred to as second reflection surfaces **1721**, **1722**, and **1723**) that generate a reflected sound by which a part of a sound going out of the booth main body **12** from the inside of the booth main body **12** through the area changing portion **16** is reflected back toward the inside of the area changing portion **16**. For this reason, a part of the sound traveling to go out of the booth main body **12** through the area changing portion **16** is reduced by the reflection

surfaces **1721**, **1722**, **1723** of the area changing portion **16**. Therefore, the reflected sound and the traveling sound may interfere with each other, and the sound pressure of the sound going out from the inside of the booth main body **12** to the outside of the booth main body **12** is weakened.

(49) The reflection surfaces **1711**, **1721** are in the second area portion **162**, the reflection surfaces **1712**, **1722** are in the fourth area portion **164**, and the reflection surfaces **1713**, **1723** are in the sixth area portion **166**. In the present embodiment, each of the reflection surfaces **1711**, **1712**, **1713**, **1721**, **1722**, **1723** is formed by a combination of a surface parallel to the floor surface F and a surface adjacent to the surface and parallel to the center axis C and orthogonal to the floor surface F. The reflection surfaces **1711**, **1712**, **1713**, **1721**, **1722**, **1723** may be formed of one surface or a plurality of surfaces. The reflection surface **1711**, **1712**, **1713**, **1721**, **1722**, **1723** may be formed as a curved surface.

(50) FIG. **5** (depicting a region V of FIG. **4**) shows a cylindrical body **30**, which is a part of the communication portion **14** and the area changing portion **16** indicated by region V in FIG. **4**. It is assumed that the air flow direction in the cylindrical body **30** is a direction from the upper side to the lower side in FIG. **5**. At this time, the inner wall of the cylindrical body **30** corresponding to a part of the area changing portion **16** has a flow passage having a first small area portion **311**, a large area portion **32**, and a second small area portion **312** along the air flow direction.

(51) At the boundary between the first small area portion **311** and the large area portion **32** of the cylindrical body **30** to form a step portion shown in FIG. **5**, and at the boundary between the large area portion **32** and the second small area portion **312** to form another step portion, the medium in which the sound propagates changes. Therefore, the acoustic impedance of the sound changes in the step portion.

(52) The area of the first small area portion **311** of the cylindrical body **30** shown in FIG. **5** in a direction orthogonal to the air flow direction is denoted by Aa, and the area of the second small area portion **312** in the direction orthogonal to the air flow direction is denoted by Ac. In this case, the area Aa=Ac. The area of the large area portion **32** in the direction orthogonal to the air flow direction is formed to be an area Ab larger than each of the first small area portion **311** and the second small area portion **312**. When λ is a wavelength of sound, an area ratio m=Ab/Aa=Ab/Ac between the areas Aa and Ac of the first and second small area portions **311** and **312** and the area Ab of the large area portion **32**, a coefficient k=2π/λ, and L is a length of the large area portion **32** along the air flow direction (that is, the distance between the first small area portion **311** and the second small area portion **312**), an attenuation amount (dB) of sound is expressed by the following Formula (1).

Attenuation amount (dB)=10 log.sub.10{1+1/4($m−1/m$).sup.2 sin.sup.2KL}   [Formula 1]

(53) From the parameters of Formula (1), the attenuation amount of sound passing through the cylindrical body **30** depends on the length L and the area ratio m of the large area portion **32**. In a case where the area ratio m increases, the attenuation amount of the sound increases. It is preferable that the difference in size between the areas Aa and Ac of the first and second small area portions **311** and **312** and the area Ab of the large area portion **32** is large. Therefore, in order to attenuate the sound, it is preferable that the areas Aa and Ac of the first and second small area portions **311** and **312** are as small as possible and the area Ab of the large area portion **32** is as large as possible.

(54) On the other hand, based on the parameter of Formula (1), the attenuation amount of the sound passing through the cylindrical body **30** does not depend on the shapes of the first small area portion **311**, the second small area portion **312**, and the large area portion **32**. Therefore, the shapes of the first small area portion **311**, the second small area portion **312**, and the large area portion **32** can be appropriately set. Here, in order to simplify the description, an example in which a disk-like or columnar space spreads around the common central axis of the first small area portion **311**, the large area portion **32**, and the second small area portion **312** will be described. That is, in the present embodiment, the first and second small area portions **311** and **312** of the cylindrical body **30** are formed in a columnar shape or a disk shape, and the large area portion **32** of the cylindrical

body **30** is formed in a columnar shape or a disk shape.

(55) FIG. **6** shows a relationship between frequency (Hz) and sound pressure level (dB) of a general male voice and a general female voice. A human audible sound range is generally about 20 Hz to 20000 Hz. Frequencies of human voices in daily conversations are considered to be about 250 Hz to 4000 Hz. As shown in FIG. **6**, the frequencies of male voices having an appropriate sound level range from 20 Hz to 4000 Hz, and the frequencies of female voices having an appropriate sound level range from 20 Hz to 7000 Hz. For this reason, in the present embodiment, a sound having frequencies in a range from 20 Hz to 7000 Hz will be addressed.

(56) FIGS. **7** to **9** show examples of simulation results of attenuation amounts (dB) of sound passing through the cylindrical bodies **30** under the following conditions **1**, **2**, and **3** at frequencies in the range from 20 Hz to 7000 Hz.

(57) As the condition **1**, the radiuses ra and rc of the first and second small area portions **311** and **312** of the cylindrical body **30** shown in FIG. **5** are set to 0.4 m, the radius rb of the large area portion **32** is set to 0.9 m, and the length L (La) of the large area portion **32** is set to 0.22 m. Under this condition, as shown in FIG. **7**, the attenuation amount (dB) of sound became 0 in the vicinity of 800 Hz and n times thereof (n is a natural number). That is, the cylindrical body **30** (i.e., the first attenuating portion **301** in FIG. **4**) under the condition **1** does not attenuate sounds at frequencies substantially 800 Hz and n times that frequency at frequencies from 20 Hz to 7000 Hz, but attenuates sounds at the other frequencies. In other words, in the cylindrical body **30** of the condition **1**, the attenuation amount of a sound at a particular frequency and the frequencies of n times (n is a natural number) the particular frequency is smaller than that of a sound at the other frequencies.

(58) As the condition **2**, the radiuses ra and rc of the first and second small area portions **311** and **312** of the cylindrical body **30** are set to 0.4 m, the radius rb of the large area portion **32** is set to 0.8 m, and the lengths L (Lb) of the large area portion **32** is et to 0.12 m. Under this condition, as shown in FIG. **8**, the attenuations (dB) in the vicinity of the substantially 1450 Hz and n times (n is a natural number) thereof were 0. That is, the cylindrical body **30** (i.e., the first attenuating portion **302** in FIG. **4**) under the condition **2** does not attenuate sounds at frequencies substantially 1450 Hz and n times that frequency at frequencies from 20 Hz to 7000 Hz, but attenuates sounds at the other frequencies.

(59) As the condition **3**, the radiuses ra and rc of the first and second small area portions **311** and **312** of the cylindrical body **30** are set to 0.4 m, the radius rb of the large area portion **32** is set to 0.7 m, and the lengths L (Lc) of the large area portion **32** is set to 0.07 m. Under this condition, as shown in FIG. **9**, the attenuations (dB) in the vicinity of the substantially 2450 Hz and n times (n is a natural number) thereof were 0. That is, the cylindrical body **30** (i.e., the first attenuating portion **303** in FIG. **4**) under the condition **3** does not attenuate sounds at frequencies substantially 2450 Hz and n times that frequency at frequencies from 20 Hz to 7000 Hz, but attenuates sounds at the other frequencies.

(60) In this manner, a sound is input to the first small area portion **311** of each cylindrical body **30**, and then output from the second small area portion **312** after being attenuated at various frequencies except for a predetermined frequency. Therefore, each of the cylindrical bodies **30** (i.e., the first to third attenuating portions **301**, **302**, and **303**) under the above-described conditions **1-3** exhibits the effect of attenuating the sound pressure level.

(61) The radius ra of the first small area portion **311** and the radius rc of the second small area portion **312** of the cylindrical body **30** under each of the conditions **1**, **2**, and **3** are the same. This is the same as the first area portion **161**, the third area portion **163**, the fifth area portion **165**, and the seventh area portion **167** of the area changing portion **16**. Therefore, the second small area portion **312** of the cylindrical body **30** (i.e., the first attenuating portion **301**) under the condition **1** and the first small area portion **311** of the cylindrical body **30** (i.e., the second attenuating portion **302**) under the condition **2** are integrated or joined together along the air flow direction, and the second

small area portion **312** of the cylindrical body **30** (i.e., the second attenuating portion **302**) under the condition **2** and the first small area portion **311** of the cylindrical body **30** (i.e., the third attenuating portion **303**) under the condition **3** are integrated or joined together along the air flow direction, and thereby forming the area changing portion **16** as shown in FIG. **4**.

(62) In the area changing portion **16**, the area SB of the second area portion **162**, the area SD of the fourth area portion **164**, and the area SF of the sixth area portion **166** corresponding to the three large area portions **32** of the cylindrical body **30** are different from each other.

(63) The length L under the condition **1** corresponds to the distance La for the second area portion **162** of the area changing portion **16**. The length L under the condition **2** corresponds to the distance Lb for the fourth area portion **164** of the area changing portion **16**. The length L under the condition **3** corresponds to the distance Lc for the sixth area portion **166** of the area changing portion **16**.

(64) In the area changing portion **16**, the lengths La, Lb, Lc of the second area portion **162**, the fourth area portion **164**, and the sixth area portion **166** corresponding to the three large area portions **32** of the cylindrical body **30** are different from each other. That is, a distance La between the first area portion **161** and the third area portion **163**, a distance Lb between the third area portion **163** and the fifth area portion **165**, and a distance Lc between the fifth area portion **165** and the seventh area portion **167** are different from each other.

(65) As described above, the area changing portion **16** is formed as an aggregate of different cylindrical bodies **30** forming an air flow passage.

(66) In the present embodiment, the area changing portion **16** has the first reflection surfaces **1711**, **1712**, **1713** that reflect a part of the sound entering the booth main body **12** from the outside of the booth main body **12** through the area changing portion **16** to the outside of the booth main body **12** so that the change in acoustic impedances is increased. In addition, since the area changing portion **16** includes the second reflection surfaces **1721**, **1722**, **1723** that reflects a part of the sound that is going out of the booth main body **12** from the inside of the booth main body **12** through the area changing portion **16** to the inside of the booth main body **12** so that the change in acoustic impedances is increased. In order to increase the change in acoustic impedance, it is preferable that the areas of the first reflection surfaces **1711**, **1712**, **1713** and the second reflection surfaces **1721**, **1722**, **1723** are as large as possible. As shown in FIG. **4**, the direction of the first reflection surfaces **1711**, **1712**, **1713** faces the outside of the booth main body **12** in the area changing portion **16**. As shown in FIG. **4**, the second reflection surfaces **1721**, **1722**, **1723** are directed toward the inside of the booth main body **12** within the area changing portion **16**.

(67) Next, the operation of the booth **10** according to this exemplary formed as described above will be described.

(68) The area changing portion **16** can be seen from one end to the other end, and does not block the flow of air between the inside and the outside of the booth main body **12**. For example, in a case where the booth **10** is used indoors, a user in the booth main body **12** can see the indoor ceiling through the area changing portion **16**. Therefore, air flows between the inside and the outside of the booth main body **12** through the area changing portion **16**. For example, when the booth **10** is used indoors, air having a temperature and humidity adjusted by indoor air conditioning is automatically replaced with air inside the booth main body **12**. For this reason, even in a case where air conditioning equipment is not attached to the booth **10** such as the ceiling portion **20**, the air outside the booth **10** enters the inside of the booth **10** through the area changing portion **16**. For this reason, the booth **10** according to the present embodiment prevents the inside of the booth main body **12** from becoming hot even in a hot season such as summer. Therefore, even when the booth **10** according to the present embodiment is used as, for example, a work booth or the like, installation of air conditioning equipment is not necessary, and an increase in cost of the booth **10** is prevented.

(69) In addition, as described above, air flows between the inside and the outside of the booth main body **12** through the area changing portion **16**. Thus, air is automatically replaced with air inside

the booth main body **12**. Therefore, the booth **10** according to the present embodiment prevents the odor from staying in the booth main body **12**.

(70) In the area changing portion **16** of the booth **10** according to the present embodiment, for example, the cylindrical body **30** (i.e., the first attenuating portion **301**) of the condition **1**, the cylindrical body **30** (i.e., the second attenuating portion **302**) of the condition **2**, and the cylindrical body **30** (i.e., the third attenuating portion **303**) of the condition **3** are integrated. As described above, the cylindrical body **30** of the condition **1** makes the attenuation amount of sound at a particular frequency and frequencies n times (n is a natural number) the particular frequency smaller than the attenuation amount of sound at the other frequencies. In the cylindrical body **30** of the condition **2**, the attenuation amount of sound at another particular frequency and frequencies n times said another frequency is smaller than the attenuation amount of sound at the other frequencies. In the cylindrical body **30** of the condition **3**, the attenuation amount of sound at yet another particular frequency and frequencies n times said yet another particular frequency is smaller than an attenuation amount of sound at the other frequencies. For this reason, the area changing portion **16** obtains the attenuation characteristics of the sound shown in FIG. **10** by the principle of superimposition of the attenuation amounts (dB) of sound by the cylindrical body **30** under the condition **1**, the condition **2**, and the condition **3** shown in FIGS. **7** to **9**.

(71) As shown in FIG. **10**, there are no frequencies at which the attenuation amount (dB) is 0 (dB) in a predetermined range of frequencies from 20 Hz to 7000 Hz in the area changing portion **16**. Therefore, at any frequencies from 20 Hz to 7000 Hz, the sound pressure of the sound input to one end of the area changing portion **16** and output from the other end is always attenuated at the other end with respect to the one end. For example, in area changing portion **16**, the sound at 800 Hz and frequencies of n times that frequency is not attenuated in the cylindrical body **30** (i.e., the first attenuating portion **301**) under the condition **1**, but is attenuated in the cylindrical body **30** (i.e., the second attenuating portion **302**) under the condition **2** and the cylindrical body **30** (i.e., the third attenuating portion **303**) in condition **3**.

(72) For example, in the area changing portion **16**, the sound at 800 Hz and n times that frequency is not attenuated in the cylindrical body **30** (i.e., the first attenuating portion **301**) under the condition **1**, but is attenuated in the cylindrical body **30** (i.e., the second attenuating portion **302**) under the condition **2** and the cylindrical body **30** (i.e., the third attenuating portion **303**) under the condition **3**. For example, in the area changing portion **16**, the sound of 2450 Hz and n times that frequency is attenuated in the cylindrical body **30** under the condition **1** and the condition **2**, and is not attenuated in the cylindrical body **30** under the condition **3**.

(73) In the present embodiment, sounds other than 800 Hz, 1450 Hz, 2450 Hz and sounds having frequencies n times as high as these frequencies, which pass through the area changing portion **16**, are attenuated three times. On the other hand, the sounds of 800 Hz, 1450 Hz, 2450 Hz and n times higher frequencies passing through the area changing portion **16** are attenuated twice. Therefore, among the voices of the male and the female, the voices of 800 Hz, 1450 Hz, 2450 Hz, and the frequencies that are n times those frequencies reach the inside of the booth main body **12** after being attenuated in a case where the voices pass through the area changing portion **16** from the outside of the booth main body **12**.

(74) Therefore, when the flow passage of the air communicating the inside and outside of the booth main body **12** is formed by the area changing portion **16**, the sound of each frequency caused by the male and female voices generated outside the booth main body **12** is attenuated when reaching the inside of the booth main body **12** through the area changing portion **16**. In addition, in the area changing portion **16**, the sizes of the reflection surfaces **1711**, **1712**, **1713** are appropriately formed, and the directions of the reflection surfaces **1711**, **1712**, **1713** are directed to the outside of the booth main body **12**. For this reason, a part of sounds of the respective frequencies by the male and female voices generated outside the booth main body **12** is reflected by the reflection surfaces **1711**, **1712**, **1713** when passing through the area changing portion **16**. Therefore, a part of the

sound travelling towards the inside of the booth main body **12** from the outside of the booth main body **12** does not reach the inside of the booth main body **12**. Further, the wall plate **121** of the booth **10** exhibits a sound absorbing or sound insulating function. Therefore, the inside of the booth **10** becomes a quiet individual room space compared with the outside of the booth **10**. Therefore, a user of the booth **10** inside the booth **10** can perform, for example, work in a quiet environment.

(75) In addition, the sound having each of the frequencies corresponding to male and female voices generated inside the booth main body **12** attenuates in a case where the sound reaches the outside of the booth main body **12** through the area changing portion **16**. In the area changing portion **16**, the sizes of the reflection surfaces **1721**, **1722**, **1723** are appropriately formed, and the directions of the reflection surfaces **1721**, **1722**, **1723** are directed to the inside of the booth main body **12**. Therefore, a part of sounds of respective frequencies by male and female voices generated inside the booth main body **12** is reflected by the reflection surfaces **1721**, **1722**, **1723** when passing through the area changing portion **16**. Therefore, a part of the sound traveling out from the inside to the outside of the booth main body **12** does not reach the outside of the booth main body **12**. Further, the wall plate **121** of the booth **10** exhibits a sound absorbing or sound insulating function. Therefore, even if a large sound is generated in the booth **10**, the sound propagates as a small sound to the outside of the booth **10** as compared with the inside of the booth **10**. Therefore, for example, when a user of the booth **10** inside the booth **10** speaks in a web conference, a telephone call, or the like, it is possible to prevent the voice or sound in the booth **10** from leaking to the outside of the booth **10**.

(76) Preferably, the areas SA, SC, SE, SG of the first, third, fifth, and seventh areas **161**, **163**, **165**, **167** of the area changing portion **16** are as small as possible, and the areas SB, SD, SF of the second, fourth, and sixth areas **162**, **164**, **166** are as large as possible. In such a case, the area changing unit **16** can increase an attenuation effect of sound propagation from the outside to the inside of the booth **10** and sound propagation from the inside to the outside of the booth **10**.

(77) Further, the area changing portion **16** can be formed such that each of the first reflection surfaces **1711**, **1712**, **1713** and the second reflection surfaces **1721**, **1722**, **1723** is large. In addition, the area changing portion **16** can direct the reflection surfaces **1711**, **1712**, **1713** toward the outside of the booth main body **12** and direct the reflection surfaces **1721**, **1722**, **1723** toward the inside of the booth main body **12**. On the other hand, when the areas SA, SC, SE, SG of the first, third, fifth, and seventh areal portions **161**, **163**, **165, 167** are too small, air does not easily flow between the inside and the outside of the booth **10**. For this reason, it is preferable that the areas SA, SC, SE, SG of the first, third, fifth, and seventh areal portions **161**, **163**, **165**, **167** are adjusted to a size in which air easily flows between the inside and the outside of the booth **10** and an appropriate sound attenuation effect is obtained.

(78) Here, with reference to FIG. **11**, a booth **710** of a comparative example in which the area changing portion **16** is not provided in the upper portion of the booth main body **712** and a simple opening **7120** is provided, will be explained. In the booth **710** of the comparative example, air inside and outside the booth main body **712** can be easily replaced. However, the booth **710** of the comparative example does not have a sound attenuating mechanism and a sound reflecting mechanism such as the area changing portion **16** of the booth **10** of the present embodiment. For this reason, there is a possibility that the sound from the outside of the booth **710** of the comparative example is reflected from, for example, the ceiling **700** inside the building, passes between the opening **7120** and the ceiling **700**, is diffracted, and enters the booth main body **712** through the opening **7120**. At this time, a mechanism for absorbing or insulating sound does not exist in an upper portion of the booth main body **712**.

(79) In the present exemplary embodiment, areas SB, SD, SF of the second area portion **162**, the fourth area portion **164**, and the sixth area portion **166** of the area changing portion **16** illustrated in FIG. **4** are different from each other. The distance La between the first area portion **161** and the third area portion **163**, the distance Lb between the third area portion **163** and the fifth area portion

165, and the distance Lc between the fifth area portion **165** and the seventh area portion **167** are different. Therefore, the booth **10** according to the present embodiment can attenuate the sound of each of the frequencies corresponding to the male and female voices entering from the outside to the inside of the booth main body **12** and from the inside to the outside of the booth main body **12**, by the area changing portion **16**. In addition, in the booth **10** according to the present embodiment, the sound emitted outside the booth main body **12** can be reflected toward the outside of the booth main body **12** by the reflection surfaces **1711**, **1712**, **1713**. In addition, in the booth **10** according to the present embodiment, the sound emitted from the inside of the booth main body **12** can be reflected toward the inside of the booth main body **12** by the reflection surface **1721**, **1722**, **1723**.

(80) For this reason, in the booth **10** according to the present embodiment, air inside and outside the booth **10** can be easily exchanged, and a favorable sound absorbing or sound insulating effect can be obtained as compared with the booth **710** of the comparative example. As described above, according to the present embodiment, it is possible to provide the booth **10** that provides a quiet area without blocking the flow of air inside and outside.

(81) In the present embodiment, an example has been described in which the reflection surfaces **1711**, **1721** are provided in the second area portion n **162**, the reflection surfaces **1712**, **1722** are provided in the fourth area portion **164**, and the reflection surfaces **1713**, **1723** are provided in the sixth area portion **166**. At least one of the reflection surfaces **1711**, **1712**, **1713**, **1721**, **1722**, **1723** may be provided depending on a usage aspect such as an installation position of the booth **10**. That is, at least one of the second, fourth, or sixth area portions **162**, **164**, **166** of the area changing portion **16** may have at least one of a first reflection surface that reflects the sound travelling to the inside of the booth main body **12** through the area changing portion **16** to the outside of the booth main body **12** or a second reflection surface that reflects the sound travelling to the outside of the booth main body **12** through the area changing portion **16** to the inside of the booth main body **12**. In such a case, the area changing portion **16** can attenuate the sound pressure of the sound passing through the area changing portion **16** by greatly changing the acoustic impedances at the boundaries between the reflection surface that reflects the sound and the first, third, fifth, and seventh area portions **161**, **163**, **165 167** adjacent to the reflection surface. In addition, the area changing portion **16** can reflect sound in a desired direction by its reflection surface.

(82) In the above description, an example of the area changing portion **16** in which the cylindrical body **30** under the condition **2** is integrated with or connected to the cylindrical body **30** under the condition **1**, and the cylindrical body **30** under the condition **3** is integrated with or connected to the cylindrical body **30** under the condition **2** has been described. For example, the cylindrical body **30** under the condition **1** may be integrated with or connected to the cylindrical body **30** under the condition **2**, and the cylindrical body **30** under the condition **3** may be integrated with or connected to the cylindrical body **30** under the condition **1**. In this way, when the area changing portion **16** is formed by using a plurality of cylindrical bodies **30**, the order of the cylindrical bodies **30** under the condition **1**, condition **2**, and condition **3** can be appropriately set.

(83) In the present embodiment, as shown in FIG. **5**, the area Ab of the large area portion **32** of the cylindrical body **30** is constant along the direction corresponding to the length L. Alternatively, as shown in FIG. **12**, the area Ab of the large area portion **32** may not be constant along that direction and is formed so as to approach the area Aa of the first small area portion **311** toward the upper side of the cylindrical body **30**, for example. In such a case, the area changing portion **16** of the booth **10** may not be symmetrical with respect to the predetermined center axis C of the communication portion **14**. When the area changing portion **16** is formed, the cylindrical body **30** shown in FIG. **12** and the cylindrical body **30** shown in FIG. **5** may be joined together.

(84) Further, as shown in FIG. **13**, the area Ab of the large area portion **32** may have a constant area Aba at a position of a predetermined distance, and an area Abb that approaches the area Aa of the first small area portion **311** from the middle toward the first small area portion **311** on the upper side of the cylindrical body **30**, for example. When the area changing portion **16** is formed, the

cylindrical body **30** shown in FIG. **13** and the cylindrical body **30** shown in FIG. **5** may be combined. Further, the area changing portion **16** may be formed by integrating or joining the cylindrical body **30** shown in FIG. **12**, the cylindrical body **30** shown in FIG. **13**, and the cylindrical body **30** shown in FIG. **5**.

(85) In the present embodiment, the area Aa of the first small area portion **311** and the area Ac of the second small area portion **312** are the same in each cylindrical body **30** as shown in FIG. **5**. Alternatively, as shown in FIG. **14**, in each cylindrical body **30**, the space area Aa of the first small area portion **311** and the space area Ac of the second small area portion **312** may be different. When the area changing portion **16** is formed, the cylindrical body **30** shown in FIG. **14** and the cylindrical body **30** shown in FIG. **5** may be combined. Further, the area changing portion **16** may be formed by integrating or joining the cylindrical body **30** shown in FIG. **12**, the cylindrical body **30** shown in FIG. **13**, the cylindrical body **30** shown in FIG. **14**, and the cylindrical body **30** shown in FIG. **5**. In this context, these space area (Aa, Ab, Ac) values correspond in general to volumes (spatial volumes) within the cylindrical body **30**.

(86) As described above, according to the present embodiment, it is possible to provide the booth **10** that provides a quiet area without blocking the flow of air inside and outside.

First Modified Example

(87) A booth **10** according to a first modified example of the first embodiment will be described with reference to FIGS. **15** and **16**.

(88) As shown in FIGS. **1** and **4**, in the booth **10** of the first embodiment, the area changing portion **16** is formed by integrating or connecting three cylindrical bodies **30** shown in FIG. **5**. In the first modified example, as shown in FIG. **15**, the booth **10** has two of the three cylindrical bodies **30** shown in FIG. **5**, which are integrated or connected along the air flow direction to form the area changing portion **16**.

(89) As shown in FIG. **15**, the area changing portion **16** of the booth **10** according to this modified example includes a first area portion **161**, a second area portion **162** having an area SB larger than the area SA of the first area portion **161**, a third area portion **163** having an area SC smaller than the area SB of the second area portion **162**, a fourth area portion **164** having an area SD larger than the area SC of the third area portion **163**, and a fifth area portion **165** having an area SE smaller than the area SD of the fourth area portion **164** in this order along the air flow direction. The areas SB and SD of the second area portion **162** and the fourth area portion **164** of the area changing portion **16** are different from each other, and the distance corresponding to the distance La between the first area portion **161** and the third area portion **163** and the distance corresponding to the distance Lb between the third area portion **163** and the fifth area portion **165** are different from each other.

(90) The area changing portion **16** shown in FIG. **15** obtains the attenuation characteristics of the sound shown in FIG. **16** by the principle of superimposition of the attenuation amounts (dB) of the sound of the cylindrical body **30** under the condition **1** and the condition **2** shown in FIGS. **7** and **8**.

(91) As illustrated in FIG. **16**, there is no frequencies at which the attenuation amount (dB) is 0 (dB) in a predetermined range of frequencies from 20 Hz to 7000 Hz. Therefore, at any frequencies from 20 Hz to 7000 Hz, the sound pressures of the sound passing through the area changing portion **16** are always attenuated.

(92) Therefore, even if the booth **10** has an air flow passage communicating the inside and the outside of the booth main body **12**, when the area changing portion **16** forms the flow passage, the sound of each frequency generated outside the booth main body **12** is attenuated when reaching the inside of the booth main body **12** through the communication portion **14**. In addition, the sound having each frequency generated inside the booth main body **12** attenuates in a case where the sound reaches the outside of the booth main body **12** through the communication portion **14**.

(93) The sound attenuation amount of the area changing portion **16** depends on the number of the cylindrical bodies **30** connected to each other and the shape of the cylindrical body **30** forming the area changing portion **16**.

(94) In addition, a part of the sound generated outside the booth main body **12** is reflected by the reflection surfaces **1711**, **1712** when passing through the area changing portion **16**. Therefore, a part of the sound travelling toward the inside of the booth main body **12** from the outside of the booth main body **12** does not reach the inside of the booth main body **12**. Further, the wall plate **121** of the booth **10** exhibits a sound absorbing or sound insulating function. Therefore, the inside of the booth **10** becomes a quiet individual room space compared with the outside of the booth **10**. Therefore, a user, e.g., a worker inside the booth **10** can enjoy a quite environment.

(95) In addition, a part of the sound generated inside the booth main body **12** is reflected by the reflection surfaces **1721**, **1722** when passing through the area changing portion **16**. Therefore, a part of the sound going out from the inside to the outside of the booth main body **12** does not reach the outside of the booth main body **12**. Further, the wall plate **121** of the booth **10** exhibits a sound absorbing or sound insulating function. Therefore, even if a large sound is generated in the booth **10**, the sound propagates as a small sound to the outside of the booth **10** as compared with the inside of the booth **10**.

(96) Therefore, the booth **10** according to the present modified example provides a quiet area without blocking the flow of air inside and outside.

(97) In the present modified examination, the reflection surfaces **1711**, **1721** are provided in the second area portion **162** and the reflection surfaces **1712**, **1722** are provided in the fourth area portion **164**. However, at least one of the reflection surfaces **1711**, **1712**, **1721**, **1722** may be provided depending on a usage aspect such as an installation position of the booth **10**. That is, at least one of the second and fourth area portions **162** and **164** of the area changing portion **16** may have at least one of a first reflection surface that reflects sound traveling toward the inside of the booth main body **12** through the area changing portion **16** to the outside of the booth main body **12** and a second reflection surface that reflects sound traveling toward the outside of the booth main body **12** through the area changing portion **16** to the inside of the booth main body **12**. In such a case, the area changing portion **16** can attenuate the sound pressure of the sound passing through the area changing portion **16** by greatly changing the acoustic impedances at the boundaries between the reflection surface for reflecting the sound and the first, third, and fifth area changing portions **161**, **163**, **165** adjacent to the reflection surface. In addition, the area changing portion **16** can reflect sound in a desired direction by its reflection surface.

(98) In the booth **10**, the area changing portion **16** may be formed by integrally forming or connecting four or more cylindrical bodies **30** shown in FIG. **5**.

Second Modified Example

(99) Next, a booth **10** according to a second modified example of the first embodiment will be described with reference to FIG. **17**.

(100) As shown in FIG. **17**, in the area changing portion **16** of the booth **10**, an area SA of the first area portion **161** orthogonal to the center axis C, an area SC of the third area portion **163**, and an area SE of the fifth area portion **165** are the same. In addition, in the area changing portion **16** of the booth **10**, an area SB of the second area portion **162** and an area SD of the fourth area portion **164** orthogonal to the center axis C are the same. On the other hand, the distance La is smaller than the distance Lb. Therefore, based on Formula (1), the fundamental frequency of the sound that cannot be attenuated is different between the cylindrical body **30** including the second area portion **162** of the area changing portion **16** and the cylindrical body **30** including the fourth area portion **164**.

(101) Therefore, according to the principle of superposition, the area changing portion **16** of the booth **10** shown in FIG. **17** has a characteristic of attenuating sound at frequencies from 20 Hz to 7000 Hz as shown in FIG. **16**, for example. Therefore, in a case where the distances La and Lb are different from each other, even in a case where the areas SB of the second area portion **162** and the areas SD of the fourth area portion **164** are the same, the area changing portion **16** of the booth **10** can attenuate sound having frequencies in the 20 Hz to 7000 Hz range passing through the area

changing portion **16**.

Third Modified Example

(102) A booth **10** according to a third modified example of the first embodiment will be described with reference to FIG. **18**.

(103) In the area changing portion **16** of the booth **10** shown in FIG. **18**, the distance La between the first area portion **161** and the third area portion **163** is the same as the distance Lb between the third area portion **163** and the fifth area portion **165**. In the area changing portion **16** of the booth **10**, the area SA of the first area portion **161** orthogonal to the center axis C, the area SC of the third area portion **163**, and the area SE of the fifth area portion **165** are the same. However, in the area changing portion **16** of the booth **10**, the area SB of the second area portion **162** and the area SD of the fourth area portion **164** orthogonal to the center axis C are different from each other. Therefore, based on Formula (1), the fundamental frequency of the sound that cannot be attenuated is different between the cylindrical body **30** including the second area portion **162** of the area changing portion **16** and the cylindrical body **30** including the fourth area portion **164**.

(104) Therefore, according to the principle of superposition, the area changing portion **16** of the booth **10** shown in FIG. **17** has a characteristic of attenuating sound at frequencies from 20 Hz to 7000 Hz as shown in FIG. **16**, for example. Therefore, in a case where the areas SB of the second area portions **162** and the areas SD of the fourth area portions **164** are different from each other, even in a case where the distances La and Lb are the same as each other, the area changing portion **16** of the booth **10** can attenuate the sound at the frequencies from 20 Hz to 7000 Hz passing through the area changing portion **16**.

(105) According to the first embodiment including each modified example, as in the example of the booth **10** shown in FIGS. **17** and **18**, the area changing portion **16** is formed by combining at least two cylindrical bodies **30**. In the area changing portion **16**, at least one of the area SB of the second area portion **162** or the area SD of the fourth area portion **164** may be different from at least one of the distance La or the distance Lb. With this configuration, the area changing portion **16** can obtain a characteristic of attenuating sound of frequencies from 20 Hz to 7000 Hz. Therefore, it is possible to suppress the sound pressure of the sound travelling towards the inside from the outside of the booth **10** through the area changing portion **16**, and to suppress the sound pressure of the sound that is going out from the inside of the booth. Therefore, the booth **10** according to the present embodiment including each of the modified examples can provide a quiet area without blocking the flow of air inside and outside.

Second Embodiment

(106) Next, a second embodiment of the booth **10** will be described with reference to FIG. **19**. The present embodiment is a further modified example of the first embodiment including each modified example.

(107) As described above, according to Formula (1), the attenuation amount of the sound passing through the cylindrical body **30** does not depend on the shapes of the first small area portion **311**, the second small area portion **312**, and the large area portion **32**. For this reason, as shown in FIG. **19**, the area changing portion **16** of the booth **10** may not be symmetrical with respect to the predetermined central axis C of the communication portion **14**.

(108) The booth **10** according to the present embodiment can also provide a quiet area without blocking the flow of air inside and outside.

Third Embodiment

(109) Next, a third embodiment of the booth **10** will be described with reference to FIG. **20**. The present embodiment is a further modified example of the first embodiment and the second embodiment including each modified example.

(110) As described above, in the booth **10** according to the first embodiment and the second embodiment, the communication portion **14** and the area changing portion **16** are provided in the ceiling portion **20** of the booth main body **12**.

(111) As shown in FIG. **20**, the communication portion **14** and the area changing portion **16** may be provided at a position away from the ceiling portion **20**. It is preferable that the communication portion **14** and the area changing portion **16** are provided in an upper portion of the booth main body **12**, i.e., a side wall plate **121**.

(112) The shape of the communication portion and the area changing portion **16** is, for example, the same as the shape shown in FIG. **4**. The areas of the first to seventh area portions **161** to **167** of the area changing portion **16** of the booth **10** according to the present embodiment are areas of surfaces parallel to the floor F and orthogonal to the air flow direction.

(113) The booth **10** according to the present embodiment can also provide a quiet area without blocking the flow of air inside and outside.

Fourth Embodiment

(114) Next, a fourth embodiment of the booth **10** will be described with reference to FIG. **21**. This embodiment is a further modified example of the first embodiment, the second embodiment, and the third embodiment including each modified example.

(115) As described above, in the first and second embodiments, the communication portion **14** and the area changing portion **16** protruding outward with respect to the ceiling portion **20** of the booth main body **12** are provided. That is, as shown in FIGS. **1** and **4**, the lower end of the area changing portion **16** is disposed on the ceiling portion **20** and the upper end of the area changing portion **16** is disposed outside the booth main body **12**.

(116) As shown in FIG. **21**, in the present embodiment, the lower end of the area changing portion **16** is disposed inside the booth main body **12**, and the upper end of the area changing portion **16** is disposed on the ceiling portion **20** of the booth main body **12**. As described above, a part of the communication portion **14** and the area changing portion **16** may not protrude outward from the ceiling portion **20**.

(117) In the third embodiment shown in FIG. **20**, the communication portion **14** and the area changing portion **16** protruding outward with respect to the upper portion of the booth main body **12** are provided. Alternatively, the communication portion **14** and the area changing portion **16** may be arranged to not protrude to the outside of the booth main body **12** by, for example, disposing the area changing portion **16** inside the booth main body **12** along the side wall plate **121**.

(118) The booth **10** according to the present embodiment can also provide a quiet area without blocking the flow of air inside and outside.

Fifth Embodiment

(119) A booth **10** according to a fifth embodiment of the present disclosure is described below with reference to FIG. **22** and FIG. **23**. FIG. **23** depicts a region XXIII of FIG. **22**. The booth **10** according to the fifth embodiment is a modified example of the booth **10** described for the first to fourth embodiments. The components or aspects having the same functions and/or properties as those of the booth **10** already described for the first to fourth embodiments are denoted by the same reference symbols, and additional description thereof is omitted.

(120) As shown in FIGS. **22** and **23**, the ceiling portion **20** is not present in the booth main body **12** of the booth **10** according to the present embodiment. In the present embodiment, a position opposite to the floor surface F side in the booth main body **12** is opened as the communication portion **14**. The area changing portion **16** is provided in the In the present embodiment, the area changing portion **16** includes a first annular body **41**, a second annular body **42**, and a third annular body **43** in order from the upper side to the lower side. Each of the first annular body **41**, the second annular body **42**, and the third annular body **43** has a ring shape having an opening at the center thereof. The openings of the first annular body **41**, the second annular body **42**, and the third annular body **43** have a circle, an ellipse, an n-gonal shape (n is three or more), or the like. The first annular body **41**, the second annular body **42**, and the third annular body **43** are formed in, for example, a plate shape. As described above, the area changing portion **16** may not be integrated.

(121) The first annular body **41** has an area SA of the first area portion **161**. The second annular

body **42** has an area SC of the third area portion **163**. The third annular body **43** has an area SE of the fifth area portion **165**. Further, the area changing portion **16** has an area SB of the second area portion **162** between the first annular body **41** and the second annular body **42**. The area changing portion **16** has an area SD of a fourth area portion **164** between the second annular body **42** and the third annular body **43**.

(122) The areas SB and SD of the second area portion **162** and the fourth area portion **164** are the same, but the distance La for the second area portion **162** along the air flow direction (i.e., the distance between the first annular body **41** and the second annular body **42**) is shorter than the distance Lb of the fourth area portion **164** along the air flow direction (i.e., the distance between the second annular body **42** and the third annular body **43**).

(123) Therefore, the area changing portion **16** according to the present embodiment has the same structure as the area changing portion **16** shown in FIG. **17**. Accordingly, the area changing portion **16** according to the present embodiment attenuates a sound entering the inside from the outside of the booth main body **12** and attenuates a sound going out from the inside of the booth main body **12** to the outside.

(124) The second annular body **42** of the area changing portion **16** has a reflection surface **1711** that reflects a part of a sound entering the booth main body **12** from the outside through the area changing portion **16** inside the communication portion **14** toward the outside of the communication portion **14**. The third annular body **43** of the area changing portion **16** has a reflection surface **1712** that reflects a part of a sound entering the booth main body **12** from the outside through the area changing portion **16** inside the communication portion **14** toward the outside of the communication portion **14**.

(125) Therefore, the sound travelling towards the inside of the booth main body **12** from the outside is reflected by the reflection surfaces **1711**, **1712**. Therefore, the area changing portion **16** can not only attenuate the sound that enters the booth main body **12** from outside but also reduce the sound by sound reflection.

(126) The first annular body **41** of the area changing portion **16** has a reflection surface **1721** that reflects a part of a sound going out of the booth main body **12** through the area changing portion **16** outside the communication portion **14** from the inside toward the inside of the communication portion **14**. The second annular body **42** of the area changing portion **16** has a reflection surface **1722** that reflects a part of a sound going out of the booth main body **12** through the area changing portion **16** outside the communication portion **14** from the inside toward the inside of the communication portion **14**. The third annular body **41** of the area changing portion **16** has a reflection surface **1723** that reflects a part of a sound going out of the booth main body **12** through the area changing portion **16** outside the communication portion **14** from the inside toward the inside of the communication portion **14**, for example.

(127) Therefore, the sound going out from the inside to the outside of the booth main body **12** is reflected by the reflection surfaces **1721**, **1722**. For this reason, the area changing portion **16** can not only attenuate the sound going out from the inside of the booth main body **12** but also reduce the sound by sound reflection.

(128) The booth **10** according to the present embodiment can also provide a quiet area without blocking the flow of air inside and outside.

(129) In the area changing portion **16** according to the present embodiment, it is sufficient that the plate-like members formed as the first annular body **41**, the second annular body **42**, and the third annular body **43** are fixed to, for example, an upper portion of the booth main body **12**. For this reason, in the booth **10** according to the present embodiment, the area changing unit **16** is easily assembled at the installation place of the booth **10**.

(130) According to the booth **10** of at least one embodiment described above, it is possible to provide a quiet area without blocking the flow of inside and outside air.

(131) While certain embodiments have been described, these embodiments have been presented by

way of example only, and are not intended to limit the scope of the invention. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. These embodiments and modifications thereof are included in the scope and gist of the invention and are included in the invention described in the claims and the equivalent scope thereof.

Claims

1. A booth comprising: one or more wall plates surrounding an internal space; a ceiling plate connected to the wall plates and above the internal space; and a communication portion connected to either the ceiling plate or an upper part of one of the wall plates and through which air flows between the internal space and an outside of the booth, wherein the communication portion includes a plurality of area portions arranged along an air flow direction and each having an opening through which the air flows, the area portions including at least first, second, third, fourth, and fifth portions in this order from the outside of the booth towards the internal space, a first area of the opening of the first portion that is perpendicular to the air flow direction is smaller than a second area of the opening of the second portion that is perpendicular to the air flow direction, a third area of the opening of the third portion that is perpendicular to the air flow direction is smaller than the second area, a fourth area of the opening of the fourth portion that is perpendicular to the air flow direction is greater than the third area, and a fifth area of the opening of the fifth portion that is perpendicular to the air flow direction is smaller than the fourth area.
2. The booth according to claim 1, wherein the communication portion includes a first surface between the first and second portions and facing the internal space.
3. The booth according to claim 2, wherein the communication portion includes a second surface between the second and third portions and facing a direction away from the internal space.
4. The booth according to claim 1, wherein the communication portion is connected to the ceiling plate at a center thereof in a direction perpendicular to the air flow direction.
5. The booth according to claim 4, wherein the communication portion protrudes from the ceiling upward.
6. The booth according to claim 4, wherein the communication portion protrudes from the ceiling downward.
7. The booth according to claim 1, wherein the communication portion is connected to the upper portion of one of the wall plates.
8. The booth according to claim 7, wherein the communication portion protrudes from the upper portion of one of the wall plates toward the outside of the booth.
9. The booth according to claim 7, wherein the communication portion protrudes from the upper portion of one of the wall plates towards the internal space.
10. The booth according to claim 1, wherein in the air flow direction, a first length of the second portion is greater than a second length of the fourth portion.
11. The booth according to claim 1, wherein in the air flow direction, a first length of the second portion is smaller than a second length of the fourth portion.
12. The booth according to claim 1, wherein the area portions further include a sixth portion between the fifth portion and the internal space, and a sixth area of the opening of the sixth portion that is perpendicular to the air flow direction is greater than the fifth area.
13. The booth according to claim 12, wherein in the air flow direction, a first length of the second portion is greater than a second length of the fourth portion, and the second length is greater than a third length of the sixth portion.
14. The booth according to claim 1, wherein the first area is equal to the third and fifth areas.
15. The booth according to claim 14, wherein the second area is greater than the fourth area.

16. The booth according to claim 14, wherein the second area is smaller than the fourth area.

17. The booth according to claim 14, wherein the second area is equal to the fourth area.

18. The booth according to claim 1, wherein the opening of each of the area portions has a cylindrical shape.

19. The booth according to claim 18, wherein a center of the opening of each of the area portions is on a line that is parallel to the air flow direction.