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54 **Loudspeaker system.**

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## Description

This invention relates to a loudspeaker system which is small but can reproduce a powerful sound of deep-low tone.

One of the conventional small loudspeaker systems which can reproduce a sound of deep-low tone has been a cascade bass-reflex system (as disclosed in JP-A-1-254097, which document forms the base for the preamble of claim 1). Fig. 6 shows a cross section of this conventional cascade bass-reflex loudspeaker system. In Fig. 6, 1 is a cabinet of a loudspeaker system, 2 is a speaker unit, 3 is a partition which divides the internal space of the aforesaid cabinet 1 into two spaces, 4 is the first space divided by the aforesaid partition 3, 5 is a second space, 6 is a first port installed on the aforesaid partition 3, and 7 is a second port installed on the back of the aforesaid cabinet 1.

Fig. 7 is an equivalent circuit of the loud speaker system shown in Fig. 6. In Fig. 7, Z represents an impedance comprising a mass attributable to the speaker unit 2, a compliance, and a resistance, C1 does a compliance at the first space 4, P1 does a mass at the first port 6, C2 does a compliance at the second space 5, and P2 does a mass at the second port 7.

In the loudspeaker system constructed as above, the first space 4 and port 6 and the second space 5 and port 7, namely, two compliances and two masses additionally provide a system of two degrees of freedom possessing two antiresonant frequencies  $f_1$  and  $f_2$ . Fig. 8 shows that this gives a favorable sound pressure level-frequency characteristic in the frequency ranges around  $f_1$  and from  $f_1$  to  $f_2$  by equalizing the phases of the sound radiated from the diaphragm of the speaker unit and the sound radiated from the second port 7 as in the case with a simple bass-reflex-type loudspeaker system.

A problem is, however, that, around the second antiresonant frequency  $f_2$ , the phase of the sound radiated from the second port 7 is inverted again with increasing level of sound to cause a large dip in the frequency response around  $f_2$  due to the interference with the sound radiated from the aforesaid diaphragm. This type of system can, therefore, be used as a super woofer system dedicated for the reproduction of deep-low tone, but is hardly applicable as a loudspeaker system to reproduce the entire frequency range.

JP-A-1254097, mentioned above, discloses a speaker system in which an acoustic filter is connected in cascade to a bass-reflex speaker system. The bass-reflex speaker system (a Helmholtz resonator) is constituted by a first space containing the speaker unit and a port. A second space having a hole is connected to the exit of the port to constitute the acoustic filter.

US-A-2368639 discloses a speaker system in

which a partition having a hole is provided in the cabinet to form a closed space in the cabinet. In this disclosure the speaker box of the entire speaker system is not a Helmholtz resonator, and thus the entire speaker system is not a bass-reflex speaker system.

An object of this invention is to realize a small and deep-low tone-reproducible loudspeaker system for the reproduction of the entire frequency range by eliminating the above-mentioned dip in the sound pressure level-frequency characteristic.

To attain the above object, a loudspeaker system of this invention is a cascade bass-reflex loudspeaker system which is additionally provided with a second partition on which at least one hole or port is further installed to construct a third space.

The sizes of the aforesaid third space and hole or port are adjusted so that the resonant frequency of a Helmholtz resonator composed of the aforesaid third space and a hole or port installed on the aforesaid second partition may coincide with the above-mentioned frequency  $f_2$ . This allows the aforesaid Helmholtz resonator to absorb the second antiresonance at the frequency around  $f_2$  attributable to the cascade bass-reflex system, thereby substantially improving the large dip in the sound pressure level-frequency characteristic around  $f_2$ .

Fig. 1 shows a cross section of a loudspeaker system in the first embodiment of this invention.

Fig. 2 shows an equivalent circuit of the system.

Fig. 3 shows a specific example of the sound pressure level-frequency characteristic.

Fig. 4 shows a cross section of a loudspeaker system in the second embodiment of this invention.

Fig. 5 shows a cross section of a loudspeaker system in the third embodiment of this invention.

Fig. 6 shows a cross section of a conventional loudspeaker system.

Fig. 7 shows an equivalent circuit of the system.

Fig. 8 shows a specific example of the sound pressure level-frequency characteristic.

A loudspeaker system in the first embodiment of this invention is explained below with reference to the drawings.

Fig. 1 shows a cross section of a loudspeaker system in the first embodiment of this invention, Fig. 2 does an equivalent circuit of the system, and Fig. 3 does a specific example of the sound pressure level-frequency characteristic.

In Fig. 1, a cabinet 1, a speaker unit 2, a partition 3, a first space 4, a second space 5, a first port 6, and a second port 7 are the same as each of those in Fig. 6. 8 is a second partition provided within the second space 5, 9 is a third space constructed by the second partition 8, and 10 is a hole installed on the second partition to compose a Helmholtz resonator with the third space.

In Fig. 2, Z represents an impedance comprising a mass attributable to the speaker unit 2, a compli-

ance, and a resistance, C1 does a compliance at the first space 4, P1 does a mass at the first port 6, C2 does a compliance at the second space 5, P2 does a mass at the second port 7, C3 does a compliance at the third space 9, and P3 does a mass at the hole 10.

The function of the loudspeaker system constructed as above is explained below with reference to Fig. 1, Fig. 2, and Fig. 3.

As mentioned in an example of a conventional system, a simple cascade bass-reflex loudspeaker system is additionally provided with a system of two degrees of freedom possessing two antiresonant frequencies  $f_1$  and  $f_2$  by the first space 4 and port 6 and the second space 5 and port 7 in Fig. 1, namely, two compliances C1 & C2 and two masses P1 and P2 in Fig. 2. As a result, around the second antiresonant frequency  $f_2$ , the phase of the sound radiated from the second port 7 is inverted again with increasing level of sound to cause a large dip in the frequency response around  $f_2$  due to the interference with the sound radiated from the aforesaid diaphragm. Here, if the volume of the aforesaid third space 9 and/or the size of the hole 10 is adjusted so that the resonant frequency of a Helmholtz resonator composed of the third space 9 and the hole 10 may be almost the same as the aforesaid second antiresonant frequency  $f_2$ , the second antiresonance is absorbed by the resonance of a Helmholtz resonator composed of P3 and C3 in Fig. 2. This reduces the vibration of air within the second port, thereby substantially improving the dip in the sound pressure level-frequency characteristic around  $f_2$  as shown in Fig. 3.

According to the above embodiment, a dip in the sound pressure level-frequency characteristic around the second antiresonant frequency can be substantially improved for better reproduction quality by providing a cascade bass-reflex-type loudspeaker system with a third space and a hole and, then, adjusting the volume of the aforesaid third space and the size of the hole so that the resonant frequency of a Helmholtz resonator composed of the above space and hole provided may be almost the same as the second antiresonant frequency  $f_2$ .

The second embodiment of this invention is explained below with reference to the drawings.

Fig. 4 shows a cross section of a loudspeaker system in the second embodiment of this invention.

Fig. 4 is different from Fig. 1 in that a third port 11 in place of the hole 10 is installed on the second partition 8. Even such a structure allows a Helmholtz resonator composed of the third space 9 and the third port 11 to function in a similar manner to that in the first embodiment, thereby improving the dip in the sound pressure level-frequency characteristic around the second antiresonant frequency  $f_2$ . Moreover, the resonant frequency of a Helmholtz resonator can be easily established around  $f_2$  simply by adjusting the length of the third port 11.

The third embodiment of this invention is explained below with reference to the drawings.

Fig. 5 shows a cross section of a loudspeaker system in the third embodiment of this invention.

Fig. 5 is different from Fig. 4 in that a port wall 12 composing a second port 7 is so structured that the cross-sectional area of the aforesaid port may increase gradually toward outside the cabinet 1. Such a structure allows the flow of air to be kept smooth within the port at the time of resonance in a lower range of frequency in particular, thereby reducing an acoustic noise due to the wind hissing through the port.

More than one holes or ports may be installed on the second partition in the above first, second, and third embodiments. More than one third spaces may also be constructed by providing more than one second partitions. Furthermore, the second partition may be provided in other manners than that to divide the space within the cabinet sideways such as by dividing it vertically.

## Claims

1. A cascade bass-reflex speaker system comprising a cabinet (1), a speaker unit (2) attached to a wall of the cabinet, a first partition (3) provided within the cabinet to divide the space within the cabinet into a first space (4) and a second space (5), a first port (6) provided at the first partition, and a second port (7) provided on the cabinet at a wall facing the second space,
  - characterised by further comprising a second partition (8) provided within the cabinet (1) so as to form a closed third space (9) within either the first space (4) or the second space (5), and a hole (10,11) provided at the second partition such that said third space (9) and said hole (10,11) constitute a Helmholtz resonator.
2. A speaker system according to claim 1 in which said hole is provided in the form of a port (11).
3. A speaker system according to claim 1 in which said second port (7) has a cross-sectional area gradually increasing in a direction from a central part thereof to an opening end thereof.
4. A speaker system according to claim 1, in which the volume of said third space (9) and the size of said hole (10,11) are arranged so that the resonance frequency of said Helmholtz resonator is substantially equal to an antiresonant frequency of said cascade bass-reflex speaker system.

## Patentansprüche

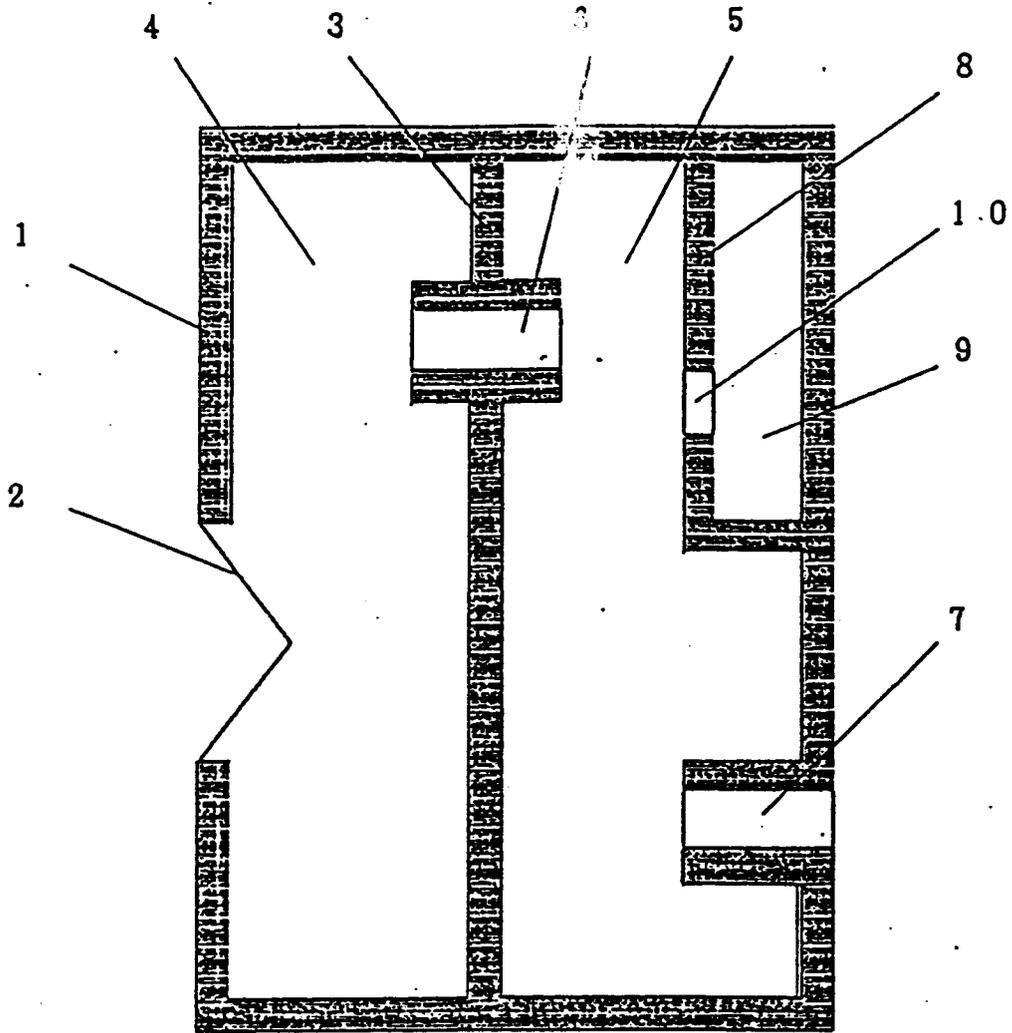
1. Ein Kaskaden-Baßreflex-Lautsprechersystem umfassend ein Gehäuse (1), eine Lautsprechereinheit (2), die an einer Wand des Gehäuses angebracht ist, eine erste Unterteilungswand (3), die in dem Gehäuse vorgesehen ist, um den Raum innerhalb des Gehäuses in einen ersten Raum (4) und einen zweiten Raum (5) zu unterteilen, eine erste Öffnung (6), die an der ersten Unterteilungswand vorgesehen ist, und eine zweite Öffnung (7), die an dem Gehäuse an einer Wand vorgesehen ist, die zu dem zweiten Raum weist, **dadurch gekennzeichnet**, daß es ferner umfaßt eine zweite Unterteilungswand (8), die in dem Gehäuse (1) so vorgesehen ist, daß ein geschlossener, dritter Raum (9) entweder in dem ersten Raum (4) oder dem zweiten Raum (5) gebildet wird, und ein Loch (10, 11), das an der zweiten Unterteilungswand so vorgesehen ist, daß der genannte dritte Raum (9) und das genannte Loch (10, 11) einen Helmholtz Resonator bilden. 5
2. Ein Lautsprechersystem gemäß Anspruch 1, in dem das genannte Loch in Form einer Öffnung (11) vorgesehen ist. 10
3. Ein Lautsprechersystem gemäß Anspruch 1, in dem die genannte zweite Öffnung (7) eine Querschnittsfläche hat, die nach und nach in Richtung von einem mittleren Teil von ihr zu einem Öffnungsende davon zunimmt. 15
4. Ein Lautsprechersystem gemäß Anspruch 1, in dem das Volumen des genannten dritten Raums (9) und die Größe des genannten Loches (10, 11) so angeordnet sind, daß die Resonanzfrequenz des genannten Helmholtz Resonators im wesentlichen gleich einer Antiresonanzfrequenz des genannten Kaskaden-Baßreflex-Lautsprechersystems ist. 20

pace clos (9) à l'intérieur soit du premier espace (4) soit du second espace (5), ainsi qu'un trou (10, 11) prévu dans la seconde cloison de façon que ledit troisième espace (9) et ledit trou (10, 11) constituent un résonateur de Helmholtz.

2. Système de haut-parleur selon la revendication 1, dans lequel ledit trou est prévu sous forme d'un orifice (11).
3. Système de haut-parleur selon la revendication 1, dans lequel ledit second orifice (7) présente une aire de section droite qui augmente graduellement selon la direction allant de sa partie centrale à son extrémité ouverte.
4. Système de haut-parleur selon la revendication 1, dans lequel le volume dudit troisième espace (9) et la dimension dudit trou (10, 11) sont prévus de façon que la fréquence de résonance dudit résonateur de Helmholtz soit sensiblement égale à la fréquence du circuit antirésonnant dudit système de haut-parleur à enceinte bass-reflex en cascade. 25

## Revendications

1. Système de haut-parleur à enceinte bass-reflex en cascade comportant une enceinte (1), un sous-ensemble formant haut-parleur (2) fixé à une paroi de l'enceinte, une première cloison (3) prévue à l'intérieur de l'enceinte pour diviser l'espace existant à l'intérieur de l'enceinte en un premier espace (4) et un second espace (5), un premier orifice (6) prévu dans la première cloison et un second orifice (7) prévu sur l'enceinte, sur une paroi qui fait face au second espace, 45  
 caractérisé par le fait qu'il comporte en outre une seconde cloison (8) prévue à l'intérieur de l'enceinte (1) de façon à former un troisième es- 50



- 1: Cabinet
- 2: Speaker unit
- 3: Partition
- 4: First space
- 5: Second space
- 6: First port
- 7: Second port
- 8: Second partition
- 9: Third space
- 10: Hole

Fig. 1

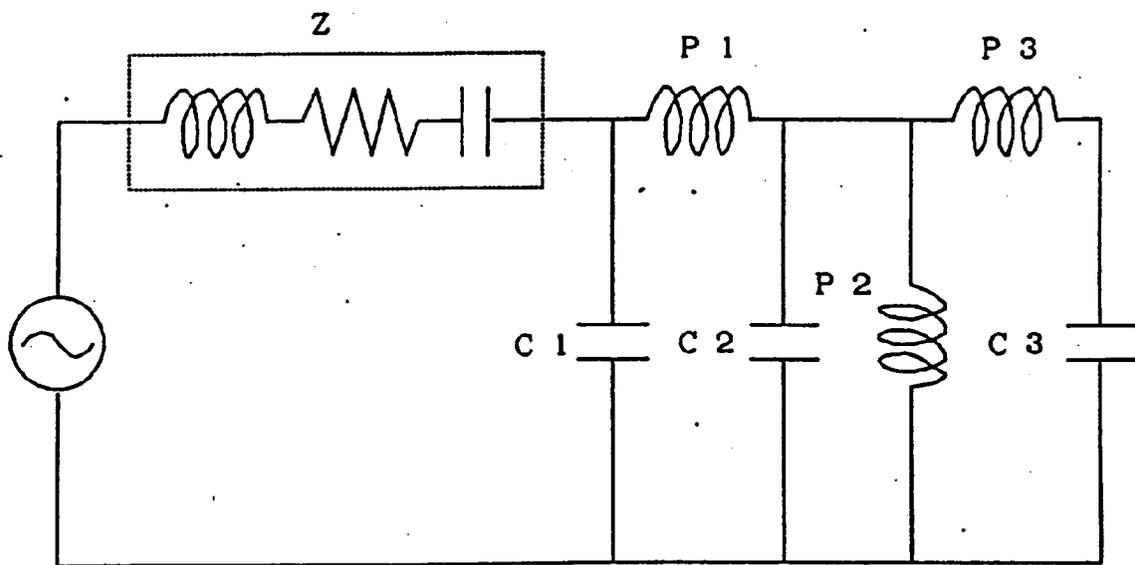


Fig. 2

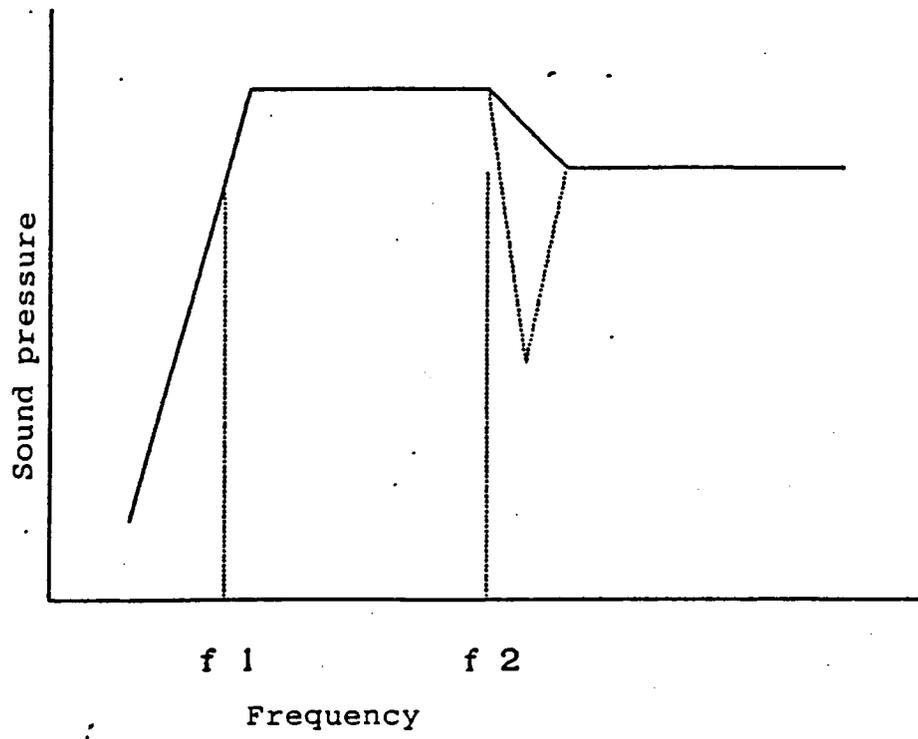
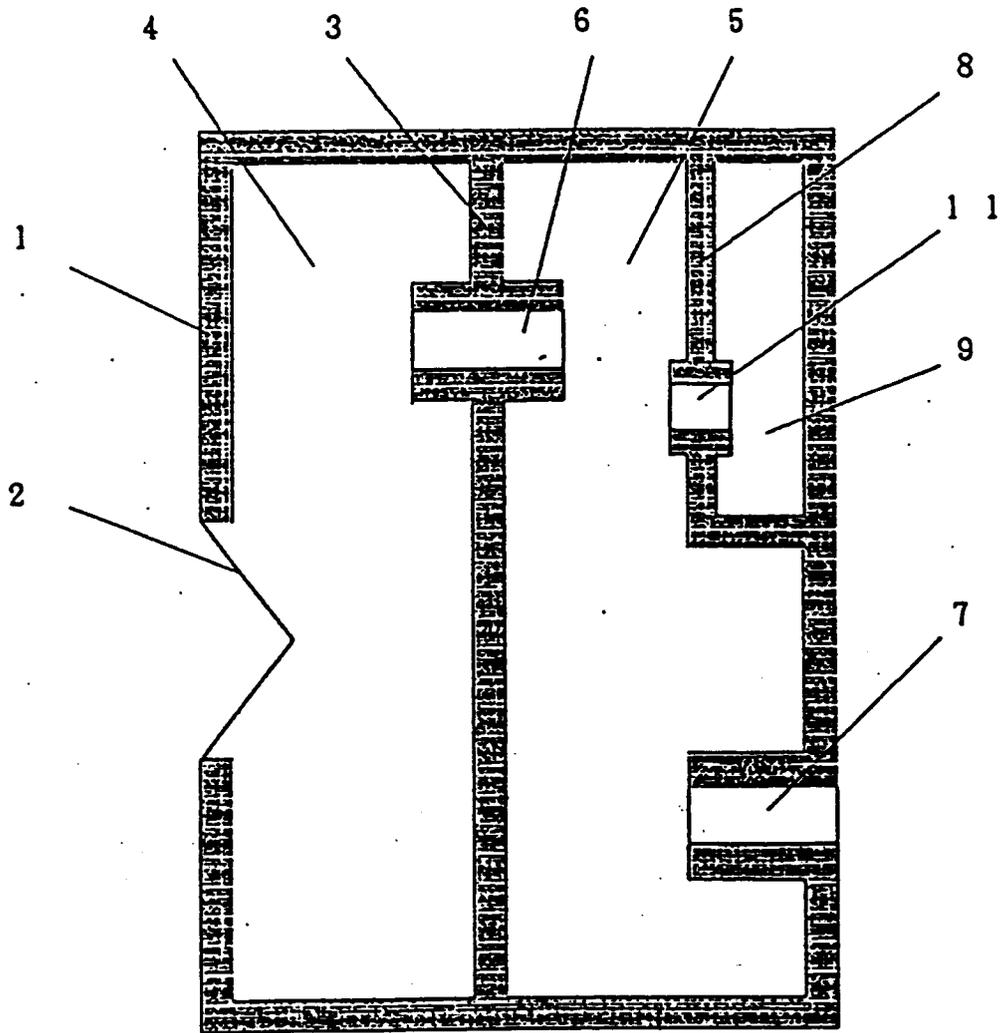
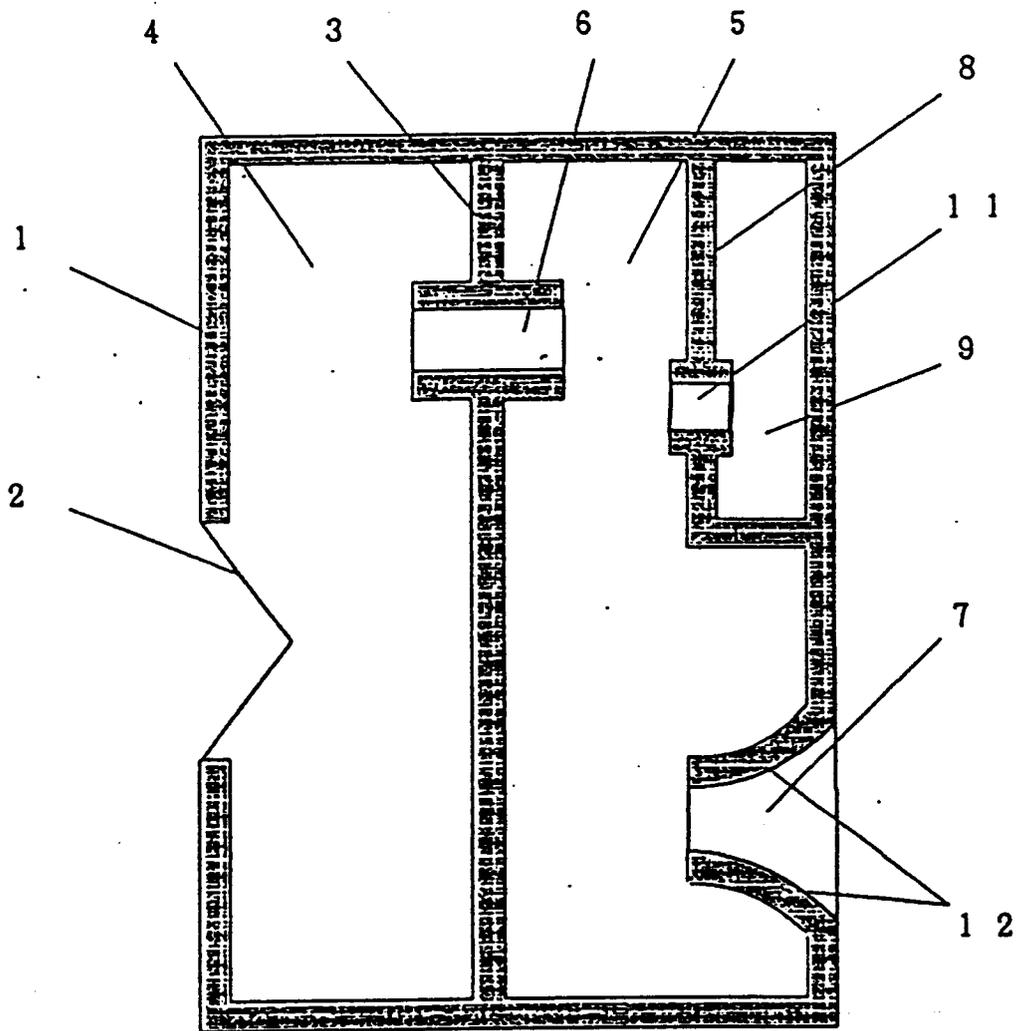


Fig. 3



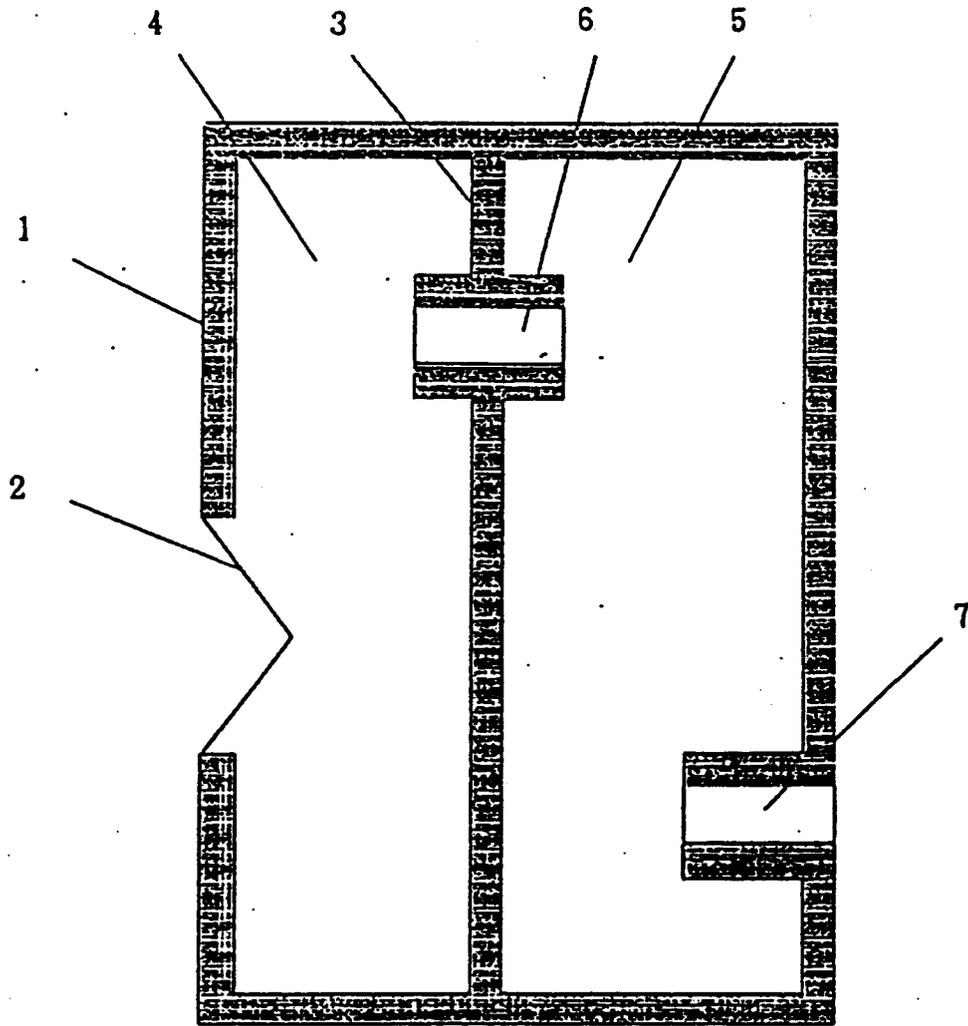
- 1: Cabinet
- 2: Speaker unit
- 3: Partition
- 4: First space
- 5: Second space
- 6: First port
- 7: Second port
- 8: Second partition
- 9: Third space
- 11: Third port

Fig. 4



- 1: Cabinet
- 2: Speaker unit
- 3: Partition
- 4: First space
- 5: Second space
- 6: First port
- 7: Second port
- 8: Second partition
- 9: Third space
- 11: Third port
- 12: Port wall

Fig. 5



- 1: Cabinet
- 2: Speaker unit
- 3: Partition
- 4: First space
- 5: Second space
- 6: First port
- 7: Second port

Fig. 6 PRIOR ART

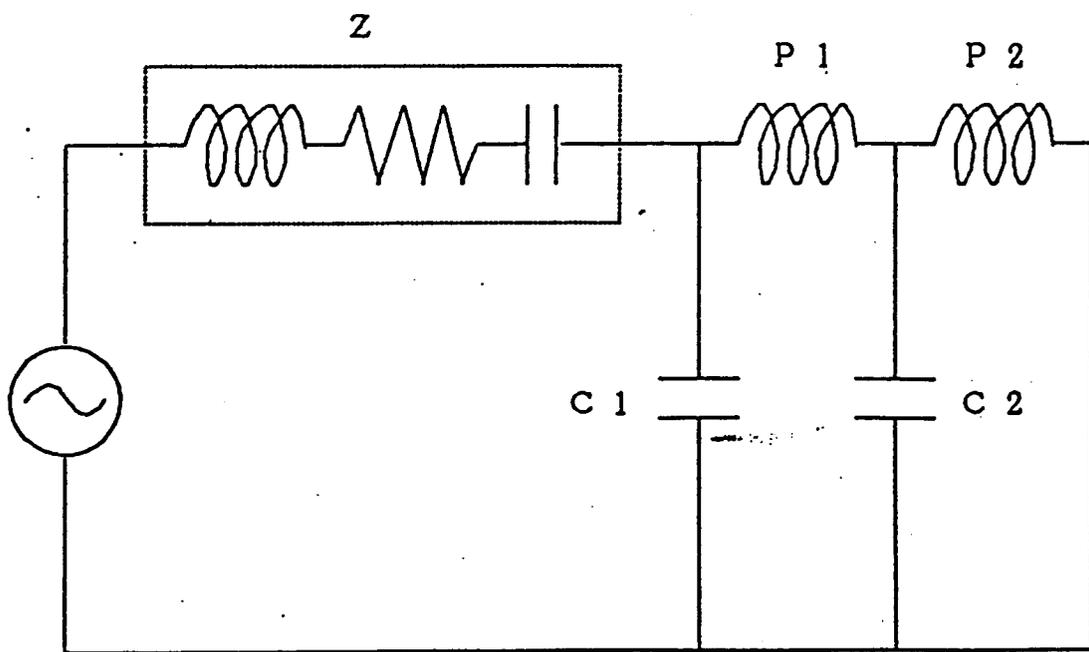


Fig. 7 PRIOR ART

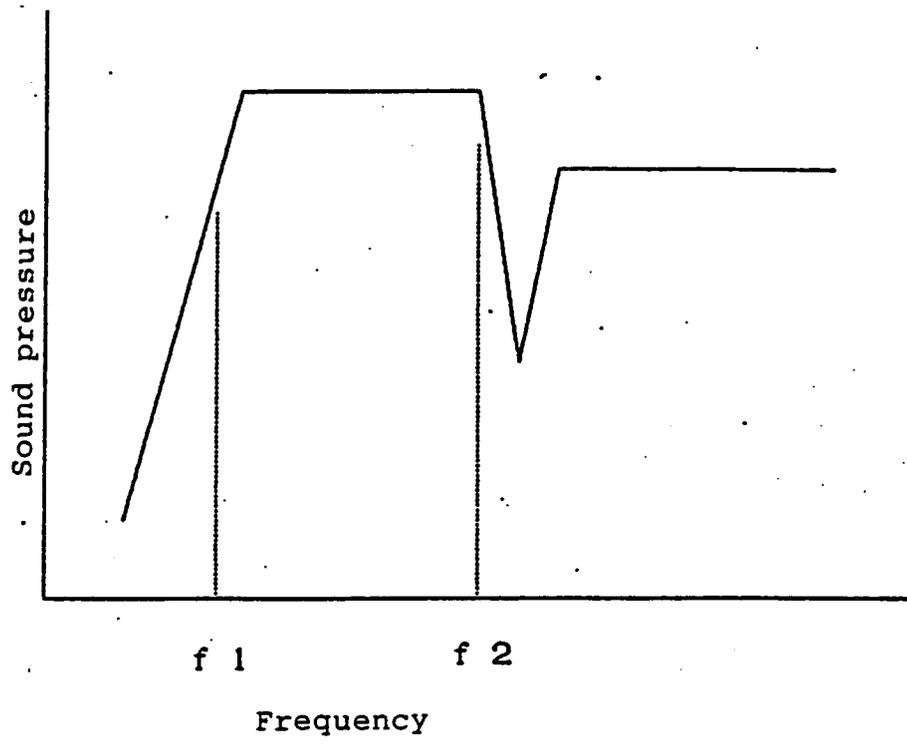


Fig. 8 PRIOR ART