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(54) Title: DIPOLE LOUDSPEAKER WITH DIFFUSE REAR RADIATION

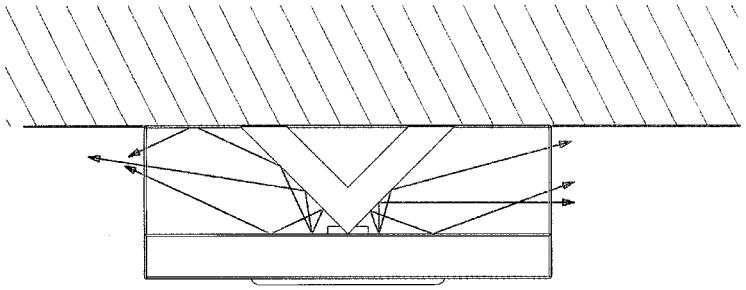

Fig. 2

(57) Abstract: The invention relates to a way to avoid the strong reflection of the wall behind the loudspeaker is to place an acoustic reflector behind the loudspeaker driver to redirect the sound away from the wall. However, the redirected sound should also be directed away from the listening position. A direction approximately perpendicular to the wall behind the loudspeaker seems to be optimal. This can e.g. be achieved by using a triangular sound reflector as depicted on the accompanying drawings. Other shapes may be applied as well.

Dipole loudspeaker with diffuse rear radiation

The invention relates to the field of audio equipment, especially loudspeakers for reproduction of audio signals. More specifically, the invention relates to the field of hi-fi loudspeakers for reproduction of stereo or multichannel signals. The invention defines a dipole loudspeaker suitable for placement very close to or directly on a wall.

A loudspeaker drive unit is traditionally mounted in a closed box to prevent the rear side radiation to reach the listener because this radiation is 180 degrees out of phase compared to the front side radiation. However, if the closed box is of limited size, then the lower cut-off frequency becomes relatively high, which in turn prevents low frequency sound reproduction. Furthermore a closed box has resonances, which makes the sound from the loudspeaker driver be non-constant as a function of frequency, i.e. local peaks and dips in the response.

A dipole loudspeaker is known to solve these problems associated by closed box loudspeaker designs. A dipole loudspeaker is open both to front radiation and rear radiation. That means that the lower cut-off frequency is as low as it can get with a given drive unit and no box resonances exists. In a dipole loudspeaker the drive unit is mounted in a baffle, which traditionally is a plane of a certain size. The baffle should prevent rear radiation from canceling the front radiation by ensuring a longer distance for the rear radiation to travel to the listening position compared to the front radiation. This yields a delay and amplitude attenuation of the rear radiated sound. The actual size of the baffle then determines the effective lower cut-off frequency of the system, i.e. to which frequency the front and rear radiation starts to cancel.

One problem with dipole loudspeakers is that they often need to be placed physically at a large distance to a wall behind the loudspeaker to avoid a strong

reflection of the rear radiated sound off the wall. This is in conflict with a desire to mount small dipole loudspeakers very close to a wall or even directly on a wall.

An object of the present invention is to solve the above mentioned problems.

This solved by the invention as defined in the claims.

A way to avoid the strong reflection of the wall behind the loudspeaker is to place an acoustic reflector behind the loudspeaker driver to redirect the sound away from the wall. However, the redirected sound should also be directed away from the listening position. A direction approximately perpendicular to the wall behind the loudspeaker seems to be optimal. This can be achieved by using a triangular sound reflector as depicted on the accompanying drawings. Other shapes may be applied as well.

Redirecting the rear radiated sound from the dipole loudspeaker almost parallel with the wall will enhance the late reflected energy experienced at the listening position because the rear radiated sound will only arrive at the listening position after multiple reflections of side walls or other surfaces in the room. This will improve the perceived sound quality because late reflected sound energy tends to open the sound image and create a sensation of a very high ceiling, i.e. the sensation of being in a very large room.

Compared to other methods of enhancing the energy in the late reflections this invention secures a null in the directivity characteristics towards the side walls. This follows from the basic principle of a dipole element, where a theoretical total cancelation exists in the baffle plane because the distance is equal to both front and rear of the loudspeaker drive unit, which is 180 degrees out of phase. Having a null in the directivity characteristics towards the side walls avoids or minimizes a strong reflection off the sidewalls, which is usually a problem with other systems for enhancing the energy of the late reflections.

The invention will now be explained more fully with reference to the drawing, in which

fig. 1 Illustrates one embodiment of the invention in which a small loudspeaker is equipped with a dipole element for high frequency reproduction,

fig. 2 Illustrates how the rear radiated sound from the dipole element is directed toward left and right sides of the loudspeaker system by reflecting off the acoustic reflector.

fig. 3 illustrates the principle behind the present invention,

fig. 4 illustrates alternative of the shaping of the acoustic rerflector.

Fig. 1 (Sheet 1 of 2) Illustrates one embodiment of the invention in which a small loudspeaker is equipped with a dipole element for high frequency reproduction (top driver). Behind this dipole element an acoustic reflector is placed such that the rear radiated sound is redirected towards the sides of the loudspeaker. The shape of the shown acoustic reflector is two plane surfaces meeting in a straight line just behind the dipole element. In the lower left hand corner of the figure is a top view of the loudspeaker, which shows the acoustic reflector as a triangle pointing forward.

Fig. 2 (Sheet 2 of 2) Illustrates how the rear radiated sound from the dipole element is directed toward left and right sides of the loudspeaker system by reflecting off the acoustic reflector. The drawing is a top view of the loudspeaker shown in Fig. 1. On the top of the figure is the wall behind the loudspeaker, while the lower part of the figure is the plane baffle in which the dipole element is

mounted. In between the wall and the dipole element is the top view of the acoustic reflector, which in this embodiment is a triangular shape.

Fig. 3 illustrated the principle behind the present invention, where a dipole element 301 is illustrated seen from above. The arrows 303 and 305 illustrates that the acoustic reflector (not shown) should have a shape with a width increasing in the direction of the arrows relative to the dipole element and away from the dipole element. Thereby the acoustic reflector reflects at least a part of the rear radiated sound away in a direction towards the side of the speaker.

In an alternative embodiment figure 3 could be an illustration of a dipole element seen from the side and the acoustic element has a shape with a width increasing in the direction of the arrows relative to the dipole element and away from the dipole element. Thereby the acoustic reflector reflects at least a part of the rear radiated sound away in a direction towards the top and bottom.

In a further embodiment the element is a combination of the above whereby the acoustic element has a shape having a width increasing in all direction whereby the reflector reflects at least a part of the rear radiated sound away in a direction towards the sides and the top and bottom.

Further to avoid radiation in one direction e.g. the bottom the width should not be increased in that direction.

The surface of the acoustic reflector could in one embodiment be smooth to ensure a precise control of the direction of the reflected sound and thereby a more precise sound. In an alternative embodiment the surface could be uneven and ruffled thereby not obtaining the same amount of control resulting in a more diffuse sound.

Fig. 4 illustrates two alternative of the shaping of the acoustic reflector, where the

reflector is shaped as a circle or sphere in figure 4a and as a parabola or circular cone in figure 4b.

In an embodiment parallel surfaces inside the speaker in the area around the dipole element could be damped by adding a damping material to these surfaces, thereby higher order reflections between the parallel surfaces is reduced, damping any sound not being transmitting in a direction almost parallel to the wall behind the speaker.

PATENT CLAIMS

1. A loudspeaker system comprising at least one dipole element combined, wherein said system further comprises an acoustic reflector positioned behind said dipole element, wherein said acoustic reflector is shaped such that it redirects at least a part of the rear radiated sound away in a direction different from a wall behind said loudspeaker and a listening position in front of said loudspeaker.

2. A loudspeaker system according to claim 1 wherein said acoustic reflector is shaped in such a way that it when placed behind said dipole element has a width increasing in a direction away from said dipole element.

3. A loudspeaker system according to claim 2 in which the acoustic reflector is a triangle shape pointing at the dipole element.

4. A loudspeaker system according to claim 2 in which the acoustic reflector is a pyramid shape pointing at the dipole element.

5. A loudspeaker system according to claim 2 in which the acoustic reflector is a cone shape pointing at the dipole element.

6. A loudspeaker system according to claim 2 in which the acoustic reflector is a sphere.

7. A loudspeaker system according to claim 1-6, wherein the surface of said acoustic reflector is smooth.

8. A loudspeaker system according to claim 1-6, wherein the surface of said acoustic reflector is ruffled.

9. A loudspeaker system according to claim 1-8, wherein in said loudspeaker parallel surfaces in the area around the dipole element is covered with damping material.

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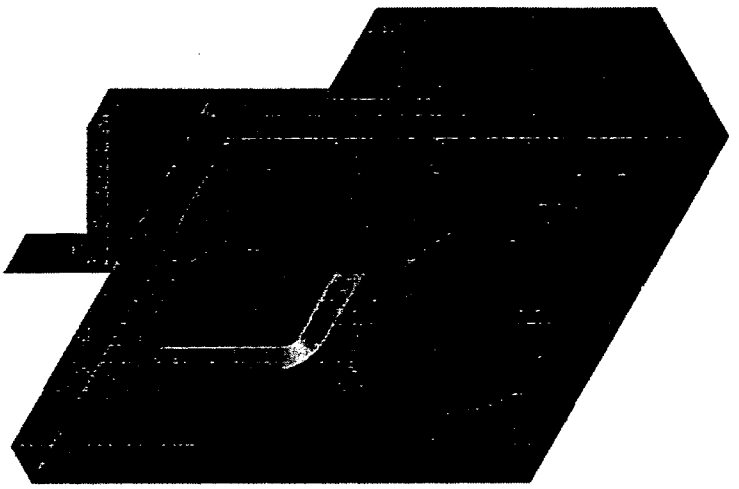
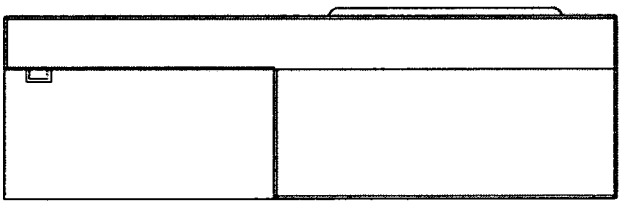
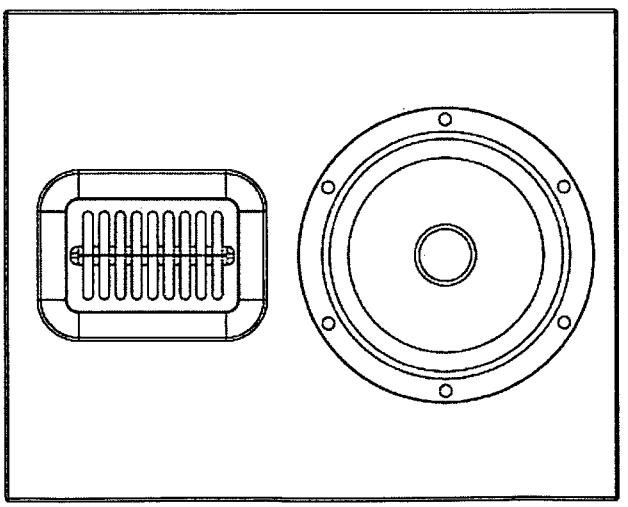
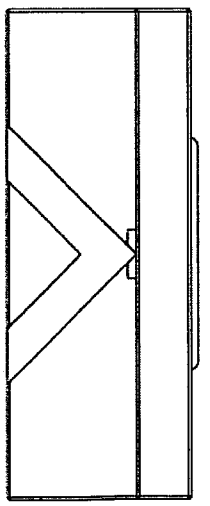


Fig. 1







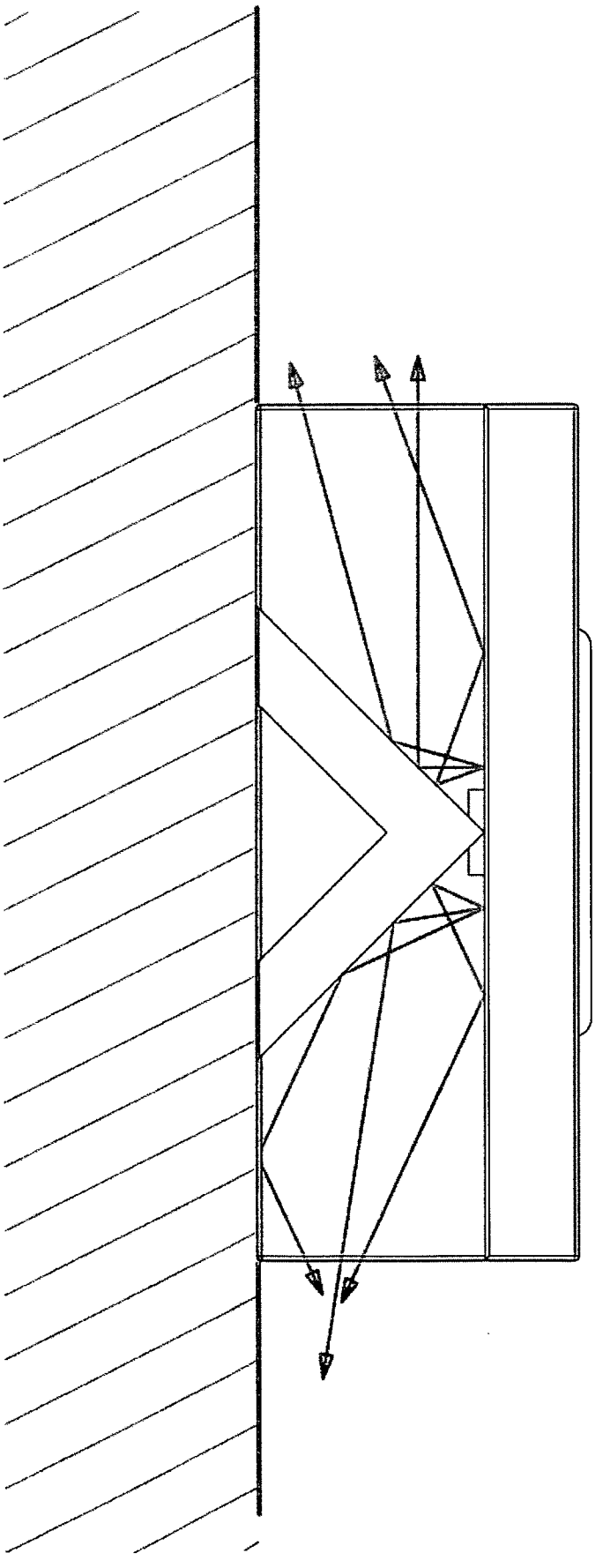


Fig. 2

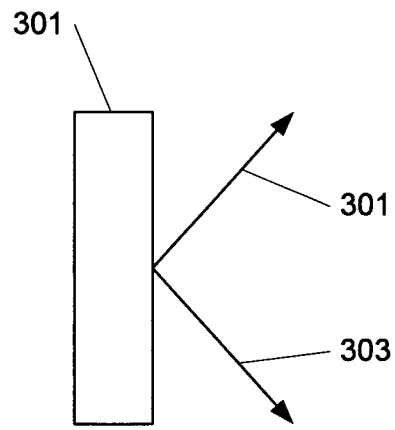


Fig. 3

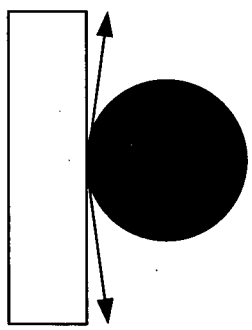


Fig. 4a

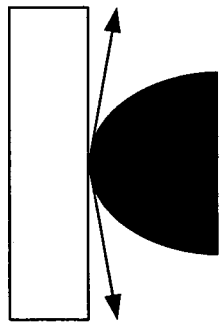


Fig. 4b

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2010/000132

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/34
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	WO 91/01074 A1 (STARK HENRIC [DE]) 24 January 1991 (1991-01-24) page 1, paragraph 4 - page 4, paragraph 2; figures 1-3	6,7

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2010	07/12/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Duffner, Orla

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2010/000132

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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