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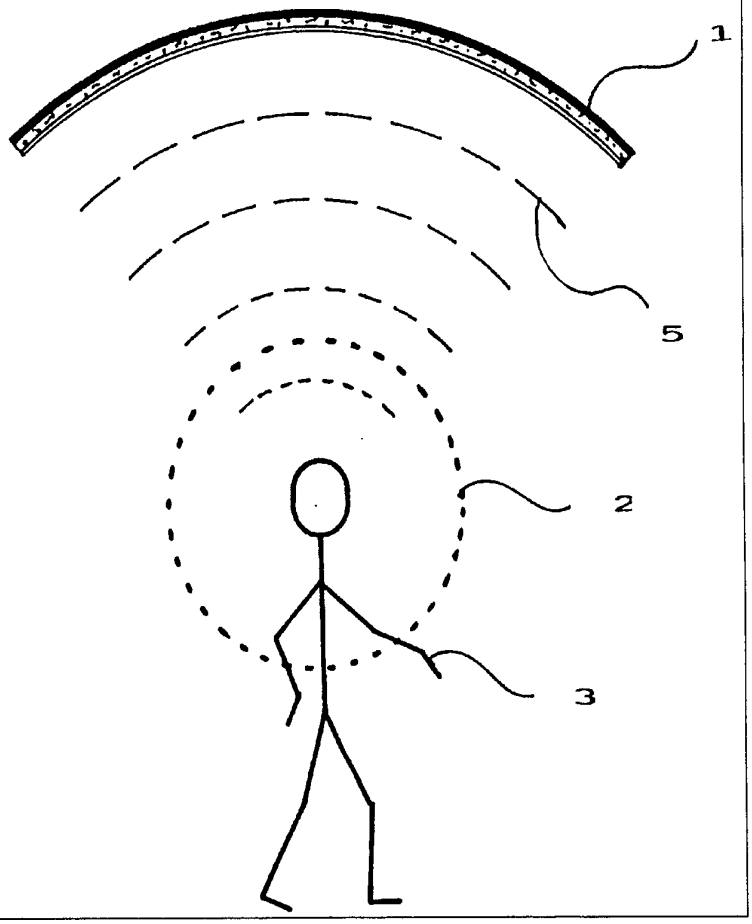
(54) Title: METHOD FOR REPEATING OF A SOUND

(57) Abstract

The object of the invention is a method for reproducing of sound, in which method a sound wave is transmitted from a sound source (1) formed by a wide-surfaced loudspeaker element to a certain direction so that the surface of the loudspeaker element is made to vibrate in phase. With the methods presently in use, it is difficult to transmit selective, distinct messages. In the method according to the invention a sound wave field (5) is transmitted by an electrostatically operating loudspeaker element (1) by making the whole surface (4) of the loudspeaker element (1) vibrate so that during vibration the direction of the normal of each point of the surface (4) stays the same as at the static state of the surface, and the loudspeaker element is shaped to focus the sound wave field evenly or focused to a certain area (2) where the target of the sound wave field or the listener (3) of the audio message is situated or moving around, in this latter case the listener experiences the audio message following him as he moves around in the sound wave field in question.



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METHOD FOR REPEATING OF A SOUND.

The object of the invention is a method for producing and focusing acoustic wave fields, especially for focusing an audio message, in which method a sound wave is transmitted from a sound source formed by a loudspeaker element with a wide surface area to a certain direction in such a way that the surface of the loudspeaker element is made to vibrate in phase and the points of the surface move in the direction of the normal to the surface.

Loudspeaker systems which are used at present have been typically constructed of dynamic loudspeaker cones which are point-like sound sources and loudspeakers constructed of them are also almost point-like sound sources. When an audio message is transmitted through such kinds of loudspeakers, a sound wave field is formed spherical in a free space so that the greatest intensity level of sound can be detected in the immediate vicinity of the loudspeaker and the intensity level falls off inversely proportionally to the square of the distance.

There are some problems connected with transmission of audio messages by point-like sound sources. For delivery of transmitted audio messages, so that the messages can be understood, it is not enough that the intensity level of sound is simply heard by the listeners. To improve the delivery of messages, it is also necessary that audio messages can be directed to those listeners to whom the contents of these messages are important. If it is intended that a point-like sound source is being used for sound reproduction where audio messages must be focused only to a certain part of the listeners, the loudspeaker has to be as near as possible to those listeners to whom the message has been directed. However, very rarely is it possible to locate loudspeakers close to the listeners in this way, thus for this reason it is not possible to transmit selective messages without disturbing other individuals in the same vicinity. When one is situating these kinds of loudspeakers, it is common that even in a

large space, only a few loudspeakers are placed far from the potential target group and in this case, high intensity levels of sound must be used to ensure the delivery of the audio message. However, the delivery of audio messages is uncertain due to many factors. The delivery of a message is disturbed, for example, by a message which has been transmitted from a remote sound source becoming indistinct due to echoing, messages getting mixed up with other extraneous noises, too great an intensity level of sound, the usual distortion of signal when the volume of sound becomes excessive, as well as other factors. Those listeners to whom the announcement is not relevant, experience it simply as unwanted sound pollution.

The aim of the invention is to bring forward a method for realizing listener selective sound reproduction, so that with such a method, sound wave fields can be produced so that the audible sound intensity level can be intentionally limited to a certain part of the area where the audio message is transmitted. In addition, the aim of the invention is to bring forward a method and, by utilizing this method, make it possible that many different audio messages can be transmitted simultaneously in the same space so that these messages do not interfere with each other and that each message is audible only in that part of the space where the message in question is meant to be heard.

The aim of the invention is achieved with the method characterized in the following claims.

According to the invention, a sound wave field is transmitted by a loudspeaker element which operates electrostatically and which has flexible insulating material between two electrodes with wide surfaces, by making the whole surface of the loudspeaker element vibrate so that during vibration the direction of the normal of every point of the surface stays the same as when the surface is in its static state. In addition, the loudspeaker element is shaped to focus the sound wave field evenly or it can be focused

to a certain space where the target of the sound wave field or the listener of the audio message is, either situated in one place or moving around; in the latter case, the listener experiences the audio message as if it were following him when he moves in the sound wave field in question. The listener in these terms is defined as a person or an animal or also some kind of device which can receive or detect acoustic audio messages. Loudspeaker elements can be shaped differently in different embodiments so that sound wave fields transmitted through them can be focused at a certain desired target. By outlining the target area and the target group of the audio message, the delivery of the message is improved and at the same time unnecessary sound pollution can be reduced. This kind of improvement is necessary when one has to make decisions on the siting of public address systems in different kinds of public spaces such as, railway and bus stations, exhibition areas, offices, sports stadiums etc. A potential application for use of focused audio messages lies in solving the problem of public announcements of department stores when, for example, at different sales areas a customer can be informed in a focused way about the products of that particular section concerned without disturbing other customers in the department store.

It is known that a point-like sound source transmits a spherical sound wave field in a free space. This phenomenon can also be utilized inversely in the method according to the invention. When a loudspeaker element with a wide surface area is shaped as a cover that is the shape of a segment, for a spherical surface, a sound wave field can be transmitted through a loudspeaker focused at the centre of the sphere such that the sound wave field gets stronger as the sound proceeds towards the mid-point of the sphere. In this way the normal of each point of the surface points to the desired focusing point. When transmitting a sound wave field in this way, a high intensity level of sound can be made stronger at the focusing point even though in the proximity of the surface of the loudspeaker element, the intensity level of sound

would not exceed the threshold of hearing. By adjusting suitably the intensity level of a sound wave, a sufficient intensity level for hearing can thus be made at the focusing point and its surroundings, although the audio message is not audible anywhere else. The intensity of a sound wave field proceeding towards the mid-point of a sphere is inversely proportional to the square of the distance from the mid-point. Thus, the intensity maximum of the sound wave field is at the mid-point of the sphere and the minimum on the surface of the sound source which lies on the cover of the sphere. By choosing suitably the intensity of the audio message transmitted by the sound source, the audio message can be made audible only near the centre of the sphere. The radius of the sphere can, when necessary, be chosen so that the spot where the sound message is audible can be far away from the sound source which transmitted the audio message. When the sound wave has passed the focusing point where it is intended, the sound wave cannot be heard any more and thus it does not burden its environment as unnecessary noise.

By using the method according to the invention, a sound wave field which stays at an even intensity level can be transmitted along a listener's route. In this way, the listener experiences the sound message as if it were following him as he moves around in the sound wave field concerned.

According to an additional embodiment of the invention, the sound wave field to be transmitted is formed by using a loudspeaker element which has been shaped as a curved surface. In this way, the sound wave field is focused on the line which is parallel to the surface and is formed of the mid-points of the radius of the curvature of the surface. By suitably adjusting the intensity level of sound, at the focus a three-dimensional tubular space can be formed where there is an intensity level which can be heard by the individual. When the listener remains in this tubular space and moves in the direction of the surface, the individual hears the

audio message as being equally loud all the time and feels as if the audio message were following him.

According to a favourable additional embodiment of the invention, a wall-like sound source is constructed by the loudspeaker element and it transmits a wall-like sound wave field which proceeds in the direction perpendicular to the sound source. When a listener enters a completely wall-like sound wave field, the intensity of sound observed by the listener does not depend on the distance between the listener and the sound source. A listener staying still or moving within the area of a wall-like sound wave field such as this experiences the sound pressure level remaining the same at different distances from the sound source.

In a favourable additional embodiment of the invention a long, wall-like sound source is constructed of a loudspeaker element and it can be placed favourably along the route of listeners, for example, on the wall or some other suitable surface in a corridor space. When a listener moves in the direction of this kind of sound source he gets an impression as if the sound source were accompanying him. Since the sound source is continuous and banded, a listener detects an audio message while moving which comes from the direction of the shortest distance from the loudspeaker and this place of the shortest distance changes as the listener moves with regard to the loudspeaker.

In a favourable additional embodiment of the invention a cylindrical sound source is constructed of a loudspeaker element and it transmits a cylinder-shaped, symmetrically balanced sound wave field from its outer surface. The loudspeaker can be placed favourably along the route of listeners, for example, on vertical pillars or columns. When a listener moves around this kind of cylindrical sound source he gets an impression as if the sound source were also moving around next to him. Since the sound source is cylindrical and continuous, the listener perceives an audio message while moving around the sound source, and the

message comes from the direction of the shortest distance from the sound source and this place of the shortest distance changes as the listener moves with regard to the sound source.

In a favourable additional embodiment of the invention, a long tubular or rod-like sound source is constructed of a loudspeaker element and it emits a cylinder-shaped, symmetrically balanced sound wave field from its outer surface. This kind of sound source can be placed along the route to be taken by the individuals, for example, on the ceiling, wall or some other suitable surface of the corridor space. As a listener moves in the direction of a sound source like this he gets an impression as if the sound source were following him. Due to the evenness of the outward proceeding cylindrical sound wave field, the audio message is perceived as being the same even though one is listening from different angles. Since the sound source is continuous and tubular, a listener perceives the audio message while moving and it comes from the direction of the shortest distance from the loudspeaker. This place of the shortest distance changes as the listener moves with regard to the loudspeaker.

In an embodiment of the method according to the invention, different audio messages are transmitted simultaneously in the same space so that each message can be heard in that part of the space where the message has been focused. In this way, the audio messages do not interfere with each other.

In the following, the invention will be explained in more detail by referring to the attached drawing in which

fig. 1 shows schematically the forming of a sound wave field by means of a curved loudspeaker element,

fig. 2 shows a detail of how the surface of a loudspeaker element moves and the direction of the movement,

fig. 3 shows a detail of movements of the surface of another loudspeaker element and the direction of the movement,

fig. 4 shows a three-dimensional embodiment of a sound wave field

fig. 5 shows an embodiment of two different sound wave fields placed in the same area,

fig. 6 shows a wall-like embodiment of a loudspeaker element,

fig. 7 shows a banded embodiment of a loudspeaker element,

fig. 8 shows a cylindrical embodiment of a loudspeaker element, and

fig. 9 shows a tubular embodiment of a loudspeaker element.

Fig. 1 is a two-dimensional representation of a sound wave field 5 produced by a curved loudspeaker element 1 which has a wide surface area and this sound wave is focused in a certain limited area 2 of the space where an audio message is transmitted and where a listener 3 is able to hear the message. In this form of the embodiment, the intensity level of the sound wave field grows as the sound waves proceed towards the focusing point.

Figs. 2 and 3 show details of cross sections of some loudspeaker elements where the direction of the movement of each point of a moving surface 4 of a loudspeaker element 1 is the same as the direction of the normal of the surface at the point in question. The loudspeaker elements consist of two electrodes 6, 7 which have wide surface areas, with a flexible layer of insulating material 8 between them. The loudspeaker element 1 shown in fig. 2 is curved, and the sound waves are transmitted in a focused way so that the sound field is homogeneous and becomes stronger. The loudspeaker element 1 shown in fig. 3 is cylindrical so that the sound wave field it forms proceeds cylinder-shaped and symmetrical. The intensity of sound is equally great in every direction at the same distance from the axis of the loudspeaker element.

Fig. 4 shows three-dimensionally a favourable embodiment of a sound wave field according to the invention. In it a focused sound wave field 5 of a curved-shaped sound source 1 with a wide

surface area, forms a three-dimensional tubular space 2 where an audio message can be heard.

Fig. 5 shows schematically a possibility for application of the method according to the invention. In the figure there are two separate curved-shaped sound sources 1A and 1B installed in the same space and they transmit simultaneously separate audio messages 5A, 5B focused at individual listeners 3A and 3B. Due to the geometry involved in the transmission of messages and application of the method according to the invention, listeners at different places perceive only those sound messages which have been transmitted to the limited spaces 2A and 2B of the places concerned.

Fig. 6 shows a favourable embodiment of a sound wave field according to the invention. In it the sound source is formed of a loudspeaker 1 which has been arranged so that it is wall-like in shape and which is situated in the vicinity of a listener 3. The loudspeaker 1 transmits a wall-like sound wave field 5 which proceeds in the direction of the normal of the loudspeaker. When a listener stays in the same place or moves within the wall-like sound wave field transmitted by the loudspeaker, the sound intensity level observed by the listener does not depend on the distance between the listener and the sound source. A listener remaining stationary or moving within the area of a wall-like sound wave field like this will experience the sound intensity level as constant at different distances from the sound source.

Fig. 7 shows a favourable embodiment of a situation according to fig. 4 or fig. 6. In it the sound source is formed of a banded loudspeaker 1 placed in the vicinity of the route of an intended listener 3. As the listener 3 moves in the sound field 5 transmitted by the loudspeaker, he gets the impression that the audio message is following him. This image is due to the phenomenon that the listener senses the direction of the strongest intensity of sound which in this case is the direction of

the shortest distance from the sound source as the direction of incidence of the audio message. When the listener moves with regard to the banded loudspeaker, also that place of the banded loudspeaker changes which is at the shortest distance from the listener.

Fig. 8 shows a favourable embodiment of a sound wave field according to the invention. In it the sound source is formed of a cylindrically shaped loudspeaker 1 and it has been situated on a column which an intended listener 3 has to go round. As the listener is moving round the column in the sound field 5 transmitted by the loudspeaker, he gets an impression as if the audio message were moving round the column along with him. This image is due to the phenomenon that the listener senses the strongest direction of the audio message which in this case is the direction of the shortest distance from the sound source as the direction of incidence of the audio message. As the listener moves around the cylindrical loudspeaker also that part of the loudspeaker changes which is at the shortest distance from the listener.

Fig. 9 shows a favourable embodiment of a sound wave field according to the invention. In it the sound source is formed of a tubularly shaped long loudspeaker 1 which has been situated in the vicinity of the route of an intended listener 3. As the listener 3 moves around in the sound field 5 transmitted by the loudspeaker, he gets the impression that the audio message is following him. In this embodiment the tubular sound source emits around it a cylinder-shaped, symmetrical, even sound wave field, the sound intensity level of which does not depend on the listener's angle of listening with regard to the sound source. As the listener 3 moves around in a cylinder-shaped symmetrical sound wave field transmitted by the loudspeaker in the direction of the axis of the cylinder he feels as if the audio message were following him.

The invention will not be limited to the described embodiments but it may vary within the frame of the innovative idea formed by the claims.

CLAIMS

1. A method for producing and focusing sound wave fields, especially for focusing an audio message, in which method a sound wave is transmitted from a sound source (1; 1A, 1B) formed by a loudspeaker element with a wide surface area in a certain direction so that the surface of the loudspeaker element is made to vibrate in phase and that the points of the surface move in the direction of the normal of the surface, characterized in that the sound wave field (5; 5A, 5B) is transmitted by an electrostatically functioning loudspeaker element (1; 1A, 1B), which has flexible insulation material (8) between two wide-surfaced electrodes (6, 7), by making the whole surface (4) of the loudspeaker element (1; 1A, 1B) vibrate so that during vibration, the direction of the normal of each point of the surface (4) stays the same as when the surface is in a static state, and that the loudspeaker element is formed to focus a sound wave field evenly or to focus it in a certain area (2; 2A, 2B) where the target of the sound wave field or the listener (3; 3A, 3B) of the audio message is situated or moving about so that the listener experiences the audio message following him when he moves around in this sound wave field.

2. A method according to claim 1, characterized in that the loudspeaker element (1; 1A, 1B) is curved-shaped to focus the sound wave field (5; 5A, 5B) in a certain limited area.

3. A method according to claim 1, characterized in that the loudspeaker element (1) is shaped wall-like to transmit a wall-like sound wave field (5) which proceeds in the direction of the normal of the surface of the loudspeaker element to a space.

4. A method according to claim 3, characterized in that the loudspeaker element (1) is long and wall-like in shape to transmit a sound wave field (5) to a certain height or level in a space.

5. A method according to claim 1, characterized in that the loudspeaker element (1) is shaped cylindrical, tubular or rod-like to transmit a sound wave field (5) symmetrical with regard to its axis to a space.

6. A method according to claim 1, characterized in that the loudspeaker element is shaped as a segment.

7. A method according to one of the claims 1-6, characterized in that different audio messages are transmitted simultaneously in the same space through different loudspeakers (1A, 1B) so that different audio messages are focused and audible in different parts of the area in question.

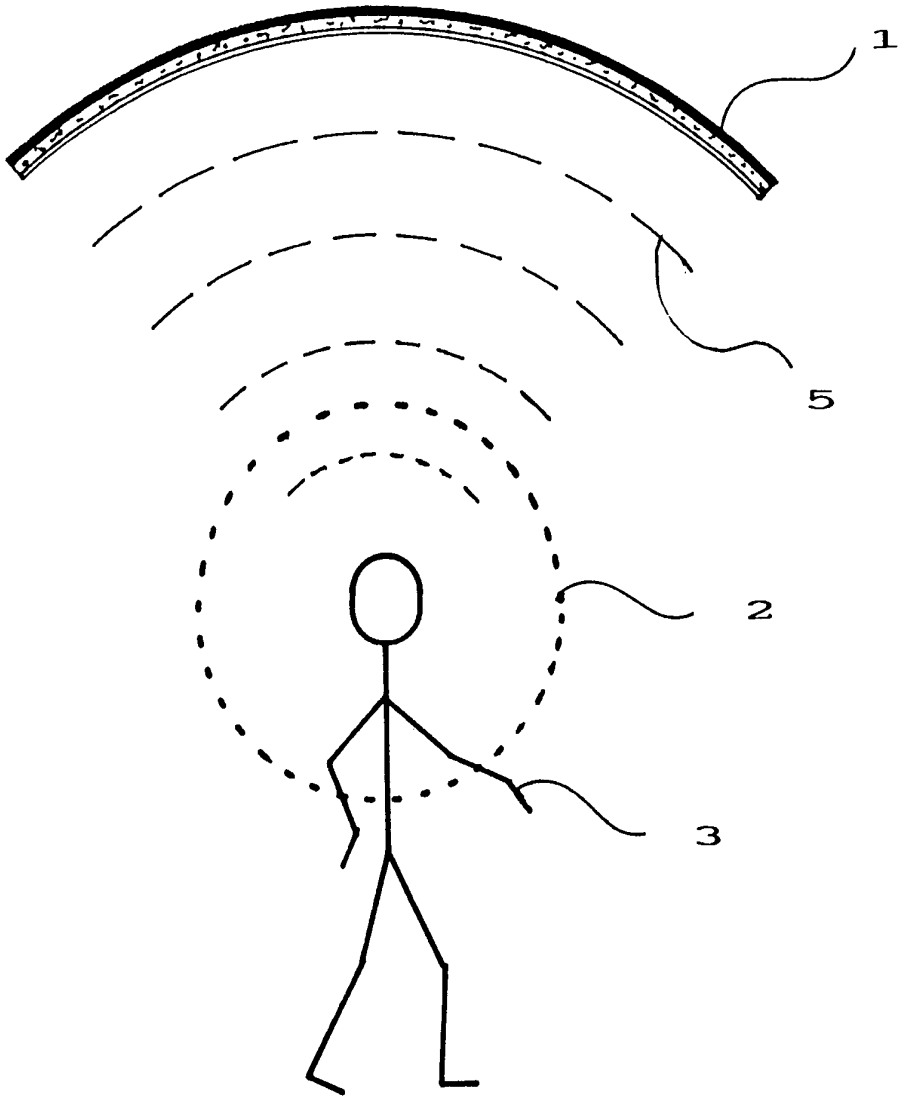

Fig. 1

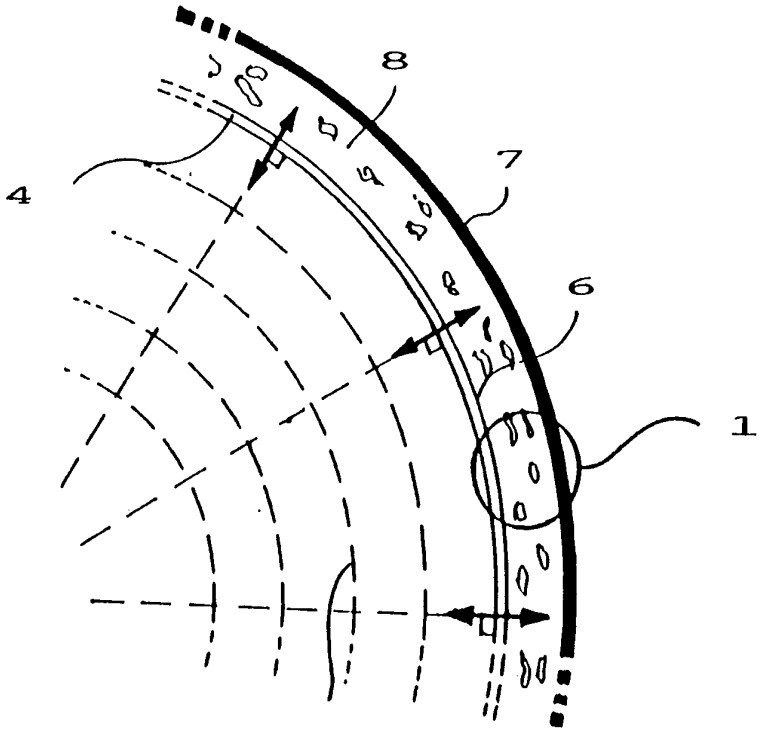

Fig. 2

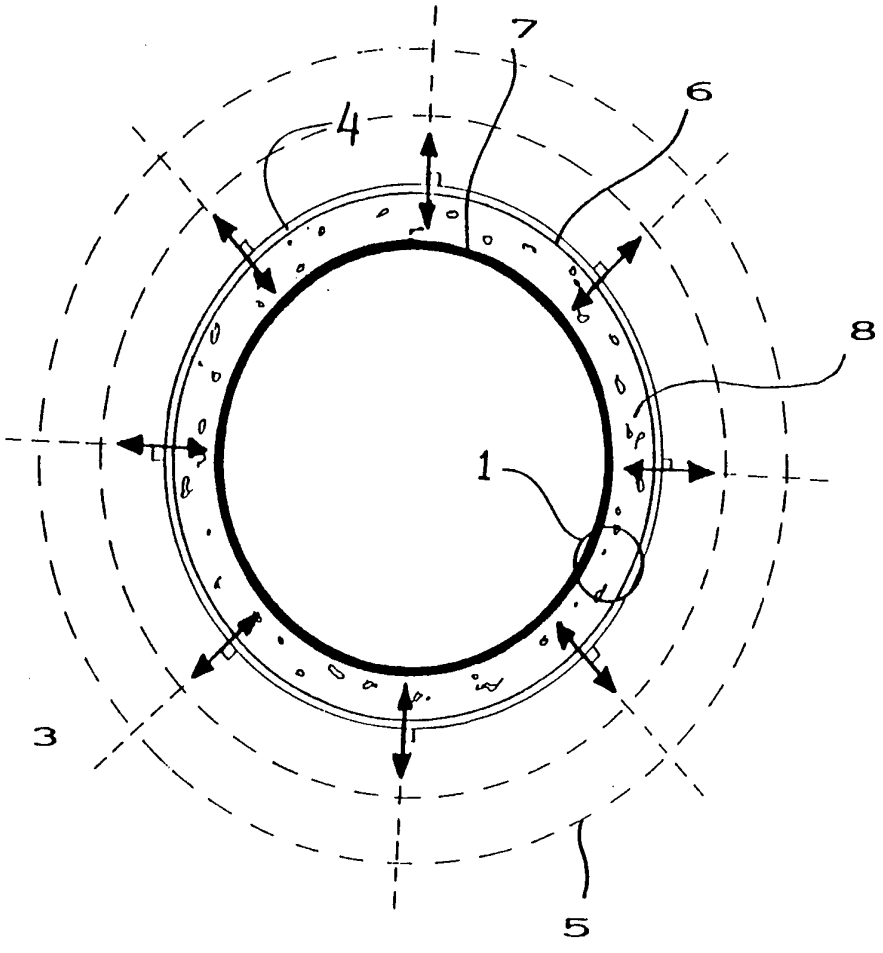

Fig. 3

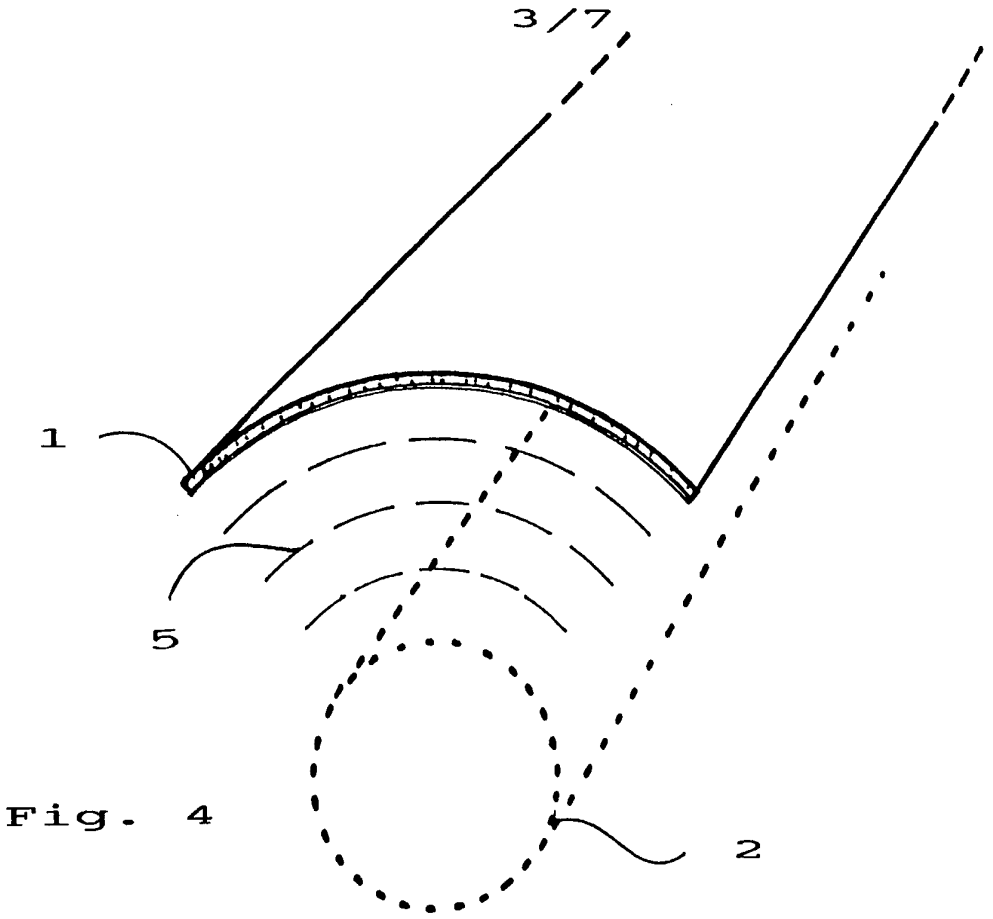

Fig. 4

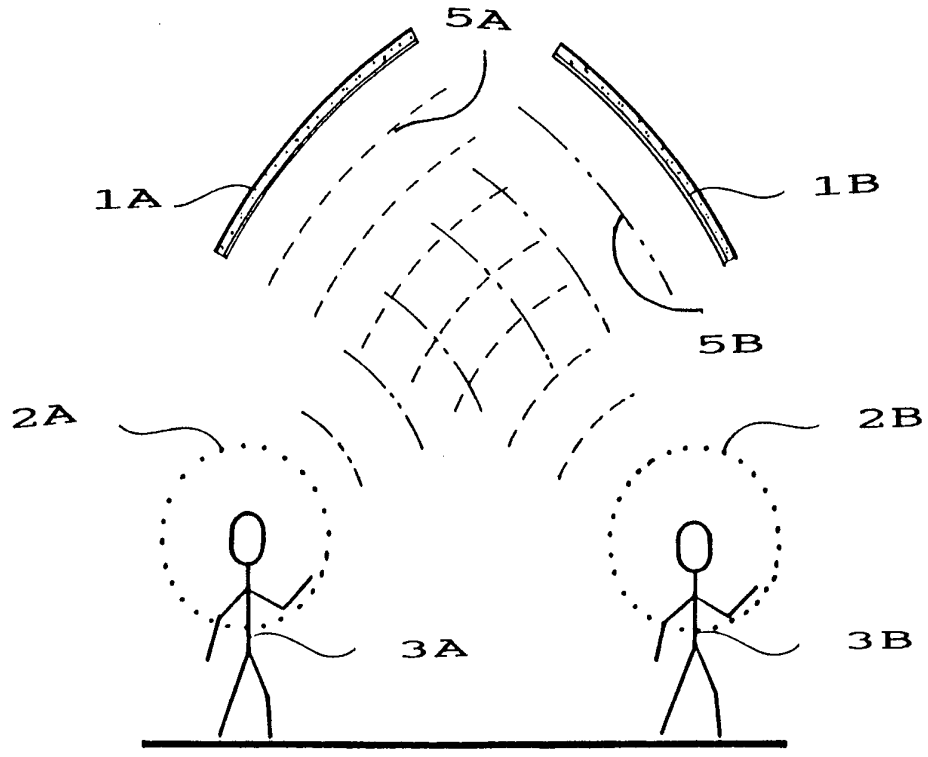

Fig. 5

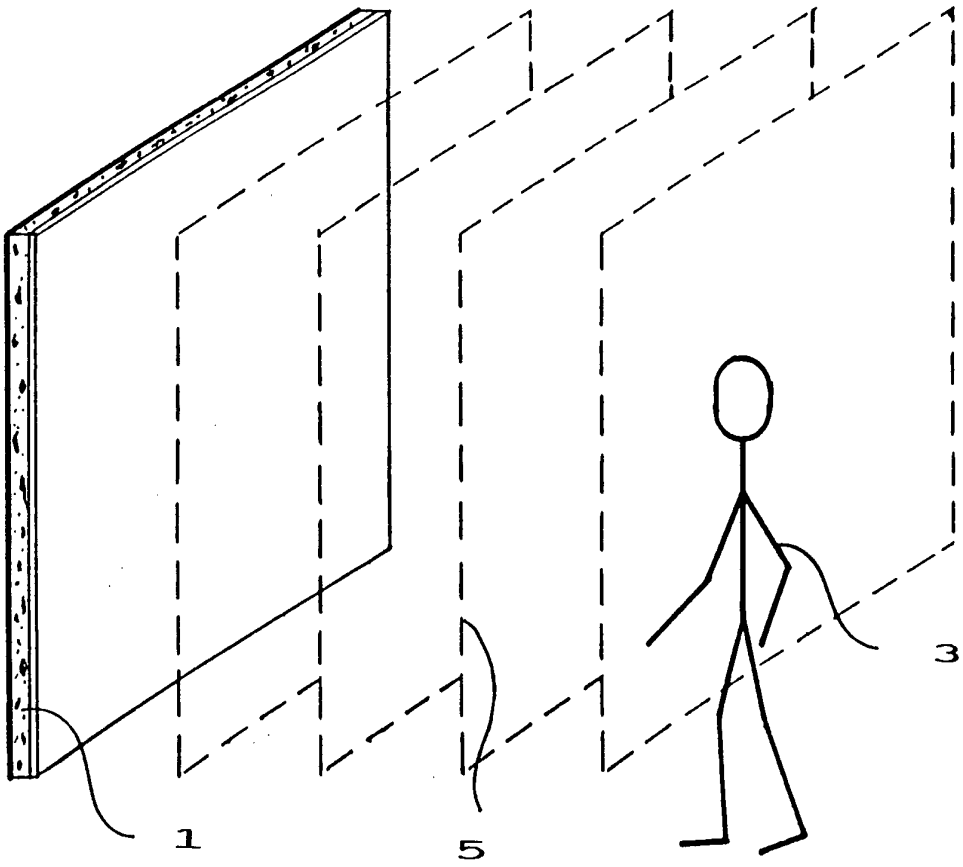

Fig. 6

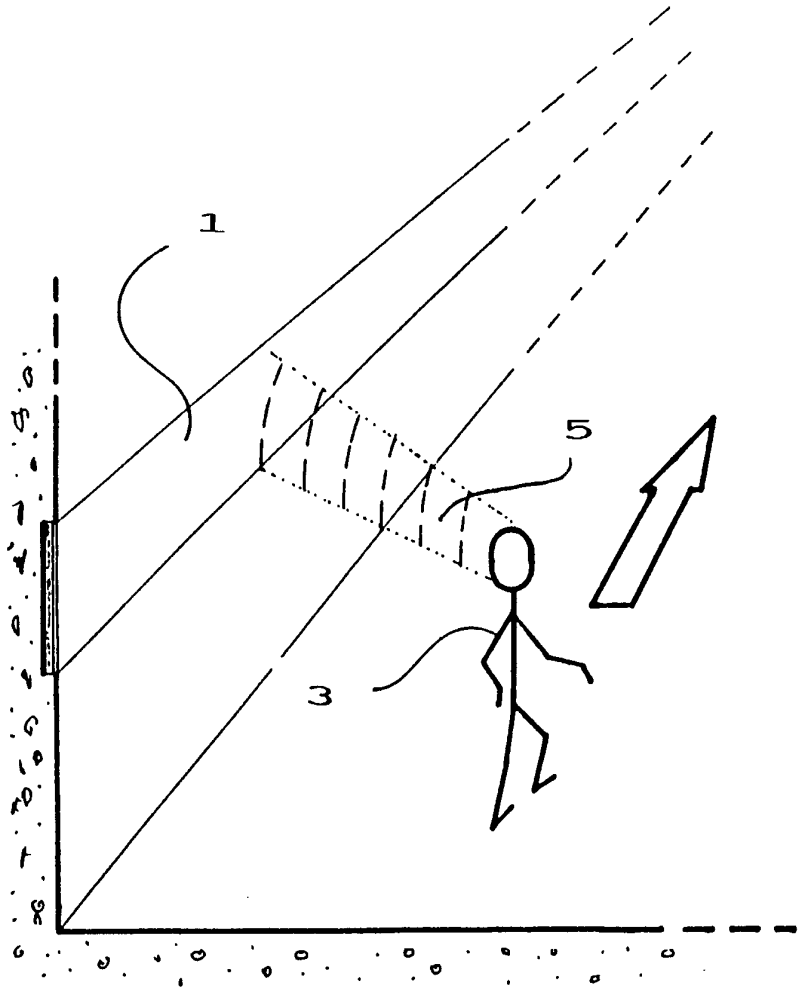

Fig. 7

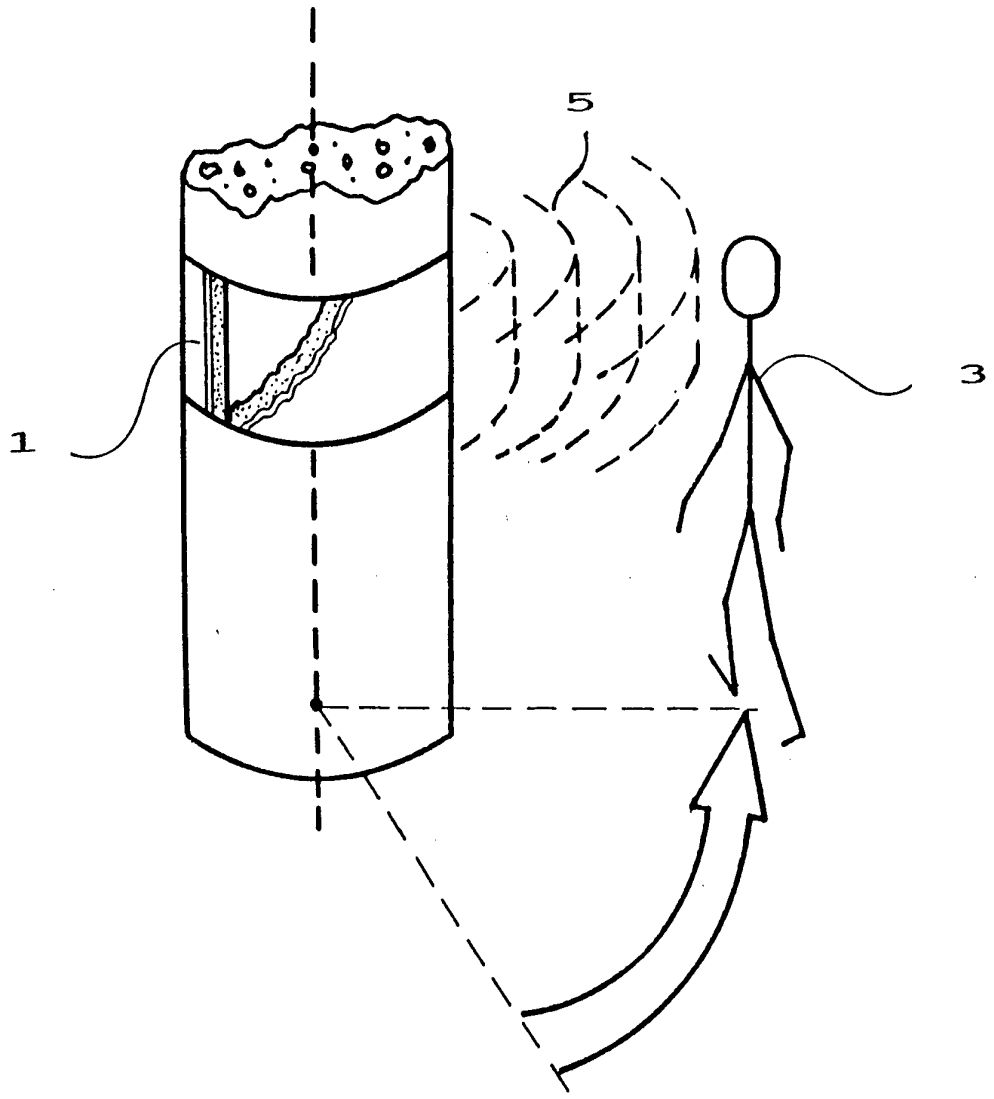

Fig. 8

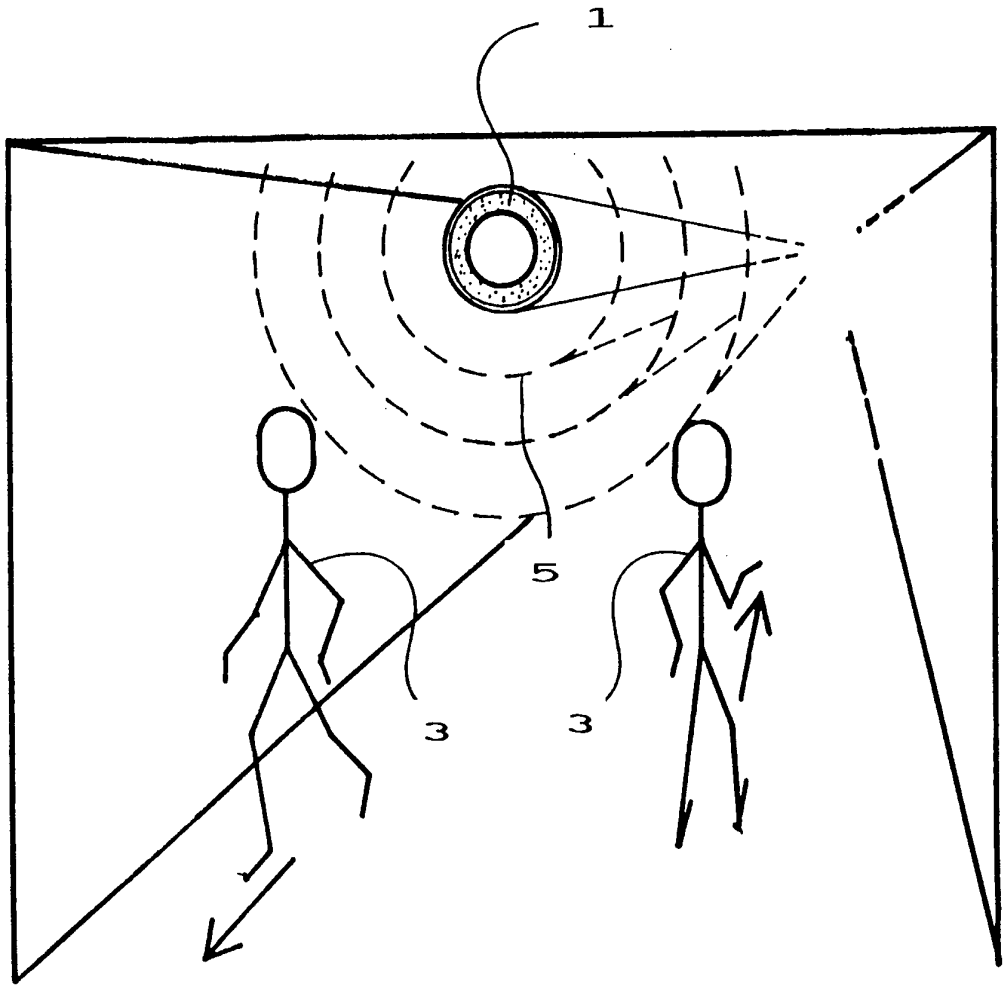

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 94/00412

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04R 1/32, H04R 19/02
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)

IPC6: H04R

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4885783 (WHITEHEAD ET AL), 5 December 1989 (05.12.89), abstract --	1-3,5,6
T	Patent Abstracts of Japan, Vol 11,No 108, E-495, abstract of JP, A, 61-253996 (MATSUSHITA ELECTRIC IND CO LTD), 11 November 1986 (11.11.86) --	2
Y	DE, A1, 3818931 (EWD ELECTRONIC-WERKE DEUTSCHLAND GMBH), 14 December 1989 (14.12.89), figure 1 --	5
Y	EP, A1, 0361249 (EWD ELECTRIC-WERKE DEUTSCHLAND GMBH), 4 April 1990 (04.04.90), abstract --	1,3

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 December 1994	28 -12- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Axel Lindhult Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). 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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INTERNATIONAL SEARCH REPORT

Information on patent family members

26/11/94

International application No.
PCT/FI 94/00412

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