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(54) Headphones fo 3D sound

(57) A headset apparatus is taught comprising at least one sound emission means, a tube connected to the sound emission means adjacent one end of the tube, and an outlet at the opposite end of the tube for positioning the outlet at a desired position adjacent a user's ear, various positions possible to achieve a variety of acoustic effects. The apparatus may comprise two or four sound emission means, with a plurality of tubes connecting the sound emission means to outlets, to effect diverse directional acoustic effects. Electronic control means may be employed to control emissions of the sound emission means, and the apparatus may comprise bass sound emission means adjacent the user's ear. Supporting means are also taught for supporting the headset apparatus on a user, such that the user's ear can be moved relative to the headset apparatus to enhance the acoustic effects.

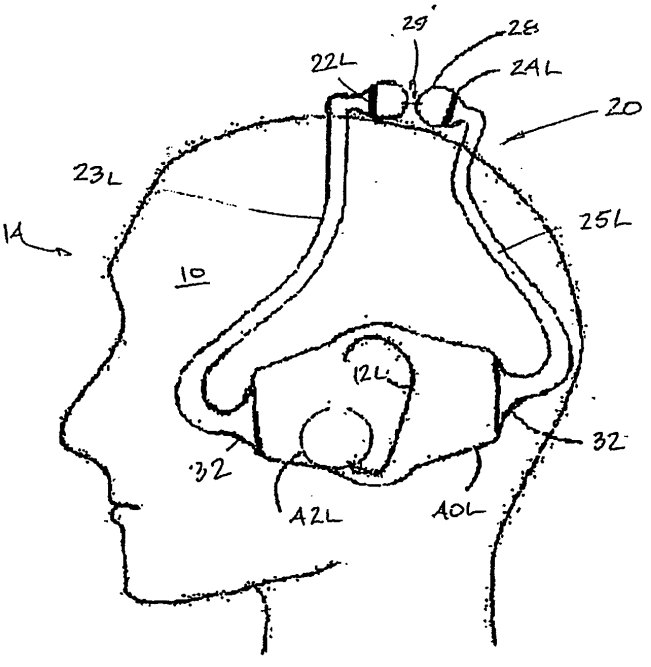

Figure 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to headphones generally, and in particular relates to headphones that simulate effects of direction and sound source.

BACKGROUND OF THE INVENTION

[0002] Conventional headphones do not account for the effects of the human outer ear to produce realistic sounds and typically make no attempt to produce the sound cues needed to locate the direction of the sound. In a theatre-type application, the sound signals from surround sound are created to be played on speakers that are in specific locations in the room. For example, one signal is created to be played on a speaker that is in front of the listener and about 45 degrees to the left. Another is created to be played on a speaker that is about the same distance from the listener but behind the listener and at approximately 60 degrees from directly behind the listener. The angle and distance from the listener creates the correct timing, intensity, pinna effect and head tracking effects to create the intended results. These effects are difficult to reproduce in headsets, due to the limited space that is available for speaker placement, and the need for compact packaging. Further, in conventional headphone design, if the speaker is not placed within a few millimetres of the ear, then the sound quality greatly diminishes.

[0003] To provide the effects of surround sound, the normal methods that humans use to locate the direction of sound have to replicated. There are four main methods that humans use, all of which are used in concert as no one method alone is adequate to pinpoint the source of the sound:

[0004] The time difference of the sound reaching each ear. If the sound is directly ahead of or behind the listener, there is no sound difference between the left and right ears receiving the sound. If the sound is directly to the right of the listener (at 90 degrees from the front of the head) the right ear hears the sound approximately 0.5ms before the left ear. So, any angle between 0 and 90 degrees creates a unique timing difference. It does not, however, distinguish between the angle in front of the ear and the same angle to the rear of the ear. Furthermore, the time difference between the ears also creates a phase difference between the signals at each ear. The time difference is the same for all frequencies but since the wavelengths vary, the phase varies with frequency.

[0005] Intensity difference. Sounds on one side of the head are louder on that side of the head. High frequency sounds are blocked by the head more than the low frequency sounds so the quality of the sound is altered to the ear opposite the sound source.

[0006] Pinna effect. The pinna is the outer ear. Sounds coming from the front of the head are reflected by the outer ear to the ear canal. Some of the sound frequencies are reflected more efficiently than others, depending on the ear size and shape, and depending on the direction of the sound. This is the main method for distinguishing between front and rear located sounds. Rear sounds are somewhat blocked by the outer ear and are muffled, while front sounds have some of the higher frequencies amplified and sound 'crisper'. Since ear shape and size is unique to each person (and for each person may even be different on left and right sides) the frequencies being amplified are different for each person.

[0007] Head tracking. Any remaining ambiguity in the use of the above methods is greatly reduced by the person rotating the head. A turn of the head changes the angle of the sound relative to the ears and so all of the above cues, timing, intensity and pinna effect, also change. The change in the cues then gives the brain a second point of view of the sound location, and greatly helps to pinpoint the sound. As little as a 5 degree turn of the head can be enough to fully pinpoint the direction of the sound.

[0008] The prior art for surround sound in headsets can be described to be in two categories.

[0009] The first category includes techniques where physical modifications to the locations of speakers are used to create surround sound, and in some cases the speakers are connected with tubes. The second category includes techniques that use one speaker at each ear and use electronic methods to alter the signals intended for the speakers to create a virtual surround sound. These methods are called Head Related Transfer Functions (HRTF). The HRTF alter the timing and intensity of the signals as described in the first two methods above. They also modify the sound so as to mimic the pinna effect. However, since every person has a unique shape to their ears (purportedly as unique as fingerprints), the way that each person has learned to detect the differences due to location are also unique to each person. The HRTF methods attempt to create a modification to sound that many people recognize as their sound cues. However, the methods cannot adapt to every person and so are limited. Other prior art describes the use of head tracking in headsets and uses a device (e.g. a gyro) to track the rotation of the head and to alter the signals to the speakers to reflect the head rotation. This requires a processor to modify the signals to replicate the desired effect.

[0010] Accordingly, it is an object of the present invention to provide a surround sound headset that overcomes the disadvantages of the prior art. It is a further object of the present invention to provide a headset that produces sounds with such timing, intensity and pinna effects as a listener would expect to hear naturally, no matter the shape and size of the listener's pinna.

SUMMARY OF THE INVENTION

[0011] According to a first aspect of the present invention, there is provided a headset apparatus comprising:

at least one first sound emission means;
at least one second sound emission means;
at least one first tube connected adjacent a first end thereof to the at least one first sound emission means;
at least one second tube connected adjacent a first end thereof to the at least one second sound emission means;
a first outlet at a second end of the at least one first tube for positioning the at least one first outlet at a first position adjacent a user ear; and
a second outlet at a second end of the at least one second tube for positioning the at least one second outlet at a second position adjacent the user ear.

[0012] In preferred embodiments of the present invention according to this first aspect, the following elements may be included: the at least one first tube is continuous with the at least one second tube at respective first ends thereof, the first and second sound emission means are speakers, the at least one first tube and the at least one second tube are of substantially the same length, the first and second outlets each flare outwardly in a direction away from the first and second tubes respectively, the first and second sound emission means are each housed within a chamber, each of the first and second outlets are provided with sound absorbing material, and/or the headset apparatus further comprises ear engaging members for housing the first and second outlets and/or at least one bass sound emission means adjacent the user ear (the latter preferably housed within an ear engaging member). The headset apparatus may comprise two first sound emission means and two second sound emission means, or three first sound emission means and three second sound emission means. In preferred embodiments of the present invention according to this first aspect where the first and second sound emission means are each housed within a chamber, the chamber is preferably a ported or vented acoustically sealed chamber, and the chamber is preferably provided with sound absorbing material on a rearwardly disposed interior surface thereof.

[0013] In preferred embodiments of the present invention according to this first aspect where the at least one first tube is continuous with the at least one second tube at respective first ends thereof, at least one of the first and second tubes is provided with sound absorbing material therein between a respective first end thereof and a respective first or second sound emission means. The sound absorbing material may either substantially or partially block the at least one of the first and second tubes.

[0014] In preferred embodiments of the present invention according to this first aspect where the headset apparatus further comprises ear engaging members for housing the first and second outlets, the ear engaging members are preferably provided with sound absorbing material on an inner surface thereof, the ear engaging members are preferably perforated, and at least one of the ear engaging members is preferably provided with a substantially vertical insert for positioning generally adjacent a centre of the user ear.

[0015] In preferred embodiments of the present invention according to this first aspect, the at least one first and second sound emission means and the at least one first and second tubes may be positioned generally on top of a user head, or the at least one first and second sound emission means and the at least one first and second tubes may be positioned in a substantially horizontal plane generally at sides of a user head. The at least one first tube and the at least one second tube may also comprise means for slidable length adjustment.

[0016] In preferred embodiments of the present invention according to this first aspect, the headset apparatus may further comprise:

at least one third sound emission means and a third tube connected thereto at a first end of the third tube for positioning a second end of the third tube at a third position adjacent the user ear; and

at least one fourth sound emission means and a fourth tube connected thereto at a first end of the fourth tube for positioning a second end of the fourth tube at a fourth position adjacent the user ear.

[0017] According to a second aspect of the present invention, there is provided a headset apparatus comprising:

at least one first sound emission means;

at least one second sound emission means;

each of the at least one first and second sound emission means having at least one first tube connected adjacent a first end thereof to the respective at least one first or second sound emission means, the at least one first tube connected at a second end thereof to a first outlet for positioning the at least one first outlet at a first position adjacent a user ear;

each of the at least one first and second sound emission means having at least one second tube connected adjacent a first end thereof to the respective at least one first or second sound emission means, the at least one second tube connected at a second end thereof to a second outlet for positioning the at least one second outlet at a second position adjacent the user ear; and

electronic control means to control emissions of the at least one first and second sound emission means.

[0018] In preferred embodiments of the present invention according to this second aspect, the headset apparatus may comprise two first sound emission means and

two second sound emission means.

[0019] According to a third aspect of the present invention, there is provided a headset apparatus comprising:

a sound emission means;
a tube connected adjacent a first end thereof to the sound emission means;
an outlet at a second end of the tube for positioning the outlet at a position adjacent a user ear; and
bass sound emission means adjacent the user ear.

[0020] In preferred embodiments of the present invention according to this third aspect, the outlet and bass sound emission means are housed within an ear engaging member.

[0021] According to a fourth aspect of the present invention, there is provided a headset apparatus comprising:

at least one first sound emission means;
at least one second sound emission means;
at least one first tube connected adjacent a first end thereof to the at least one first sound emission means;
at least one second tube connected adjacent a first end thereof to the at least one second sound emission means;
a first outlet at a second end of the at least one first tube for positioning the at least one first outlet at a first position adjacent a user ear;
a second outlet at a second end of the at least one second tube for positioning the at least one second outlet at a second position adjacent the user ear; and
supporting means for supporting the headset apparatus on a user;
such that the user ear can be moved relative to the headset apparatus.

[0022] In preferred embodiments of the present invention according to this fourth aspect, the supporting means are for positioning on shoulders of the user, and the headset apparatus further comprises ear engaging members for housing the first and second outlets. Where the headset apparatus comprises ear engaging members for housing the first and second outlets, it may further comprise adjustable connection means between the ear engaging members and the first and second outlets for enabling automatic adjustment of a connection length between the ear engaging members and the first and second outlets when the user ear is moved relative to the headset apparatus. Such adjustable connection means may comprise a slidably extensible connective member between the ear engaging members and the first and second outlets, or a flexibly extensible connective member between the ear engaging members and the first and second outlets.

[0023] According to a fifth aspect of the present invention, there is provided a headset apparatus comprising:

a sound emission means;
a first tube connected adjacent a first end thereof to the sound emission means;
a second tube connected adjacent a first end thereof to the sound emission means;
a first outlet at a second end of the first tube for positioning the first outlet adjacent a first user ear; and
a second outlet at a second end of the second tube for positioning the second outlet adjacent a second user ear.

[0024] In preferred embodiments of the present invention, a variety of advantages over the prior art may be noted:

[0025] Surround sound and full 3 dimensional effects without the limitations of the Head-Related Transfer Functions (HRTF) noted earlier, the pinna effect customized to each user's ears.

[0026] Horn-shaped tubes may be used as outlets to create an efficient transmission of sound.

[0027] The ability to overcome the restriction of having to place the headset speaker within a few millimetres of the ear and maintain the sound quality. This may be further enabled by the addition of a chamber on the rear of the speaker and is aided with the tube sound guide and the horn terminus. This technique improves the sound from any small speaker to the extent that it even makes it practical to use headset speakers as room speakers.

[0028] No need for electronic hardware to process the electrical signals to create the timing, intensity, pinna effects, or head tracking effects. The placement of the speakers in the present invention supports the correct timing. Use of damping material in the tubes between the speakers creates the intensity drop as is normally heard for sounds originating to one side of the head with the higher frequencies damped more than the low frequencies.

[0029] The ability to combine the advantages of a rear speaker chamber and tube sound guide with standard electronic methods to produce a compact headset and superior sound.

[0030] A headset according to the present invention may therefore comprise speakers that are placed in locations in tubes such that the timing and intensity location cues are correctly produced. The sound from the headset's front speakers is preferably emitted from the ends of the tubes generally in front of the user's ears so that the pinna effect for frontal sounds is correctly reproduced for every person; in this way, no matter what shape and size of the outer ear, each person hears the front sounds as they are used to hearing front sounds. Likewise, the sounds from the headset's rear speakers are preferably emitted from generally behind the ears, and so the user hears rear sounds as the user is used to hearing them.

[0031] A headset according to the present invention can produce sounds such that timing, intensity and pinna

effects are all produced in the way that every person is used to hearing those signals, no matter the shape and size of their pinna.

[0032] According to the fourth aspect of the present invention, a head tracking capability is provided. In the prior art, head tracking in certain types of headsets uses a device such as a gyro to track the rotation of the head and to alter the signals to the speakers to reflect the head rotation.

The prior art does not show head tracking capabilities for the type of headset of the present invention. In the present invention the sound signals are left unchanged. The headset rests in a generally stationary position, for example on the user's shoulders, and the user's head can move (preferably right or left by an amount of up to 20 degrees) relative to the relatively fixed points of the tube ends (outlets).

[0033] The present invention provides a headset apparatus suitable for providing a surround sound effect. The headset provides the user (also referred to herein as the "listener") with the ability to locate the direction from which sounds are originating anywhere in 3D space, much like room speakers, and provides a dynamic quality of sound. After using headsets according to the present invention, users have described other headsets as sounding "dead" by comparison. The present invention also provides a reduced "in-the-head" fatigue that is commonly experienced with prior art headsets.

[0034] A detailed description of some exemplary embodiments of the present invention is given in the following. It is to be understood, however, that the invention is not to be construed as limited to these embodiments.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0035] In the accompanying drawings, which illustrate exemplary embodiments of the present invention:

Figure 1 is a side elevation view of a headset according to one embodiment of the present invention, with the tube paths formed to meet at the top of the user's head;

Figure 2 is a top plan view of the headset of Figure 1;

Figure 3 is a top plan view of a headset according to a second embodiment of the present invention, where the tube paths are formed to meet at the front and back of a user's head;

Figure 4 is a top plan view of a headset according to a third embodiment of the present invention, having separate tubes for each speaker to the user's ears;

Figure 5 is a top plan view of a headset according to a fourth embodiment of the present invention, with the front tube replacing the rear speakers and no rear tube where the rear signals are sent directly to the speakers at the user's ears;

Figure 6 is a side elevation view of a headset according to a fifth embodiment of the present invention, with the headset resting on the user's shoulders and allowing for the head tracking feature;

Figure 7 is a detailed cross-sectional view of one embodiment of a vented rear speaker chamber which is acoustically sealed;

Figure 8 is a side elevation view of a headset according to a sixth embodiment of the present invention, illustrating the combination of acoustic features (in particular to provide the desired pinna effect) and electronic processing;

Figure 9 is a diagrammatic illustration of the wiring for the embodiment in Figure 8;

Figure 10 is a detailed cross-sectional view of one embodiment of a sliding joint within a headset tube;

Figure 11 a is a graph relating to an embodiment employing an equalizer;

Figure 11b is a chart relating to an embodiment employing an equalizer;

Figure 12 is a side elevation view of an embodiment of the present invention with an adjustable ear cup opening;

Figure 13a is a side elevation view of an embodiment of the present invention with the outlet positioned close to the user's ear; and

Figure 13b is a top plan view of the embodiment of Figure 13a.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0036] In the exemplary embodiments, speakers are placed in hollow tubes at preset locations to produce desired timing and intensity location cues. The sound from front speakers is emitted from the ends of the tubes in front of the user's ears, and so the pinna effect for frontal sounds is correctly reproduced for every user. No matter what shape and size of the outer ear, each user hears the front sounds as the user is used to hearing front sounds without such headset. Likewise, the sounds from rear speakers are emitted from behind the ears, so a user hears rear sounds as they normally would be heard.

[0037] Referring now in detail to the accompanying drawings, and specifically to the embodiment shown in Figures 1 and 2, the headset (generally designated by the reference numeral 20) is shown seated on a user's

head 10 and consists of at least one speaker and tubing to connect the acoustic path from a given speaker to one or both of the user's ears. This particular embodiment provides four speakers (which will also be referred to herein as "location" or "position generating" speakers) and associated tubing sections, namely left and right front speakers 22L and 22R (considered from the user's perspective) having respective left and right front tubing sections 23L and 23R, and left and right rear speakers 24L and 24R having respective left and right rear tubing sections 25L and 25R. As the speaker and tubing arrangement in this embodiment should be generally symmetrical about the illustrated longitudinal and transverse axes 26 and 27, one speaker and tubing arrangement will be referred to primarily to illustrate the structure and mode of operation of the present invention, and the same reference numerals will be used for the same or substantially similar components.

[0038] Referring to the speaker/tubing arrangement 22L, 23L, the speaker 22L is housed in either an acoustically sealed or a ported chamber 28.

[0039] The portion of the chamber on the backside of the speaker contains sound absorbing material 30 to reduce the echo effect in the chamber. The tube 23L may be of a constant inner diameter from its connection with the speaker toward its outlet 32 at the ear cup 40L, or alternately the tube may be shaped with an increasing diameter from speaker connection to the outlet. The outlet 32 has a flare or horn shape, as illustrated. Sound absorbing material 34 is placed within the tube 23L at its juncture with tube 23R (i.e. intermediate the front speakers 22L, 22R), to make the speaker 22L sound louder in the near side ear cup 40L for the user's near side ear 12L than in the far side ear cup 40R. The material 34 need not block the entire tube as an open channel 35 of desired size may be provided to control the amount of sound that may travel between the left and right speakers. The material 34 acts to decrease the amplitude of the higher frequencies in the same way as in room acoustics where the head acts to block the high frequencies passing from one side of the head to the ear on the opposite side of the head. Further sound absorbing material 36 is also used at the ends of the tubes 32 to reduce the standing waves that can occur with this design. The ends of the rear tubes will use more sound absorbing material than the front tubes to emulate the fact that sounds from the rear of one's head are damped by one's head of hair. The material 36 may alternately consist of a porous material, such as low density foam or felt, for example, that fills the end of the tube to provide the desired effect.

[0040] The placement of the speakers from the centreline 26 of the front and back tubes 23, 25 is now described. Each speaker 22L, 22R, 24L, 24R represents a sound source or sound emission means at a given angle from the front 14 of the head. For example, if a speaker were to represent a sound source directly in front of the listener, the speaker would be located at the centerline of the front tube 23. However, for a speaker to represent a sound source at a given angle from the front of the head, the speaker should be located at a distance "d" along the front tube 23 from the centerline 26 of the head, where:

$$d = a\,(\text{theta}+\sin(\text{theta}))/2$$

where:

a = the radius of the head, and

theta = the angle (in radians) of the source that the speaker represents.

[0041] For speakers behind the ears the same formula is used with the angle being measured from a line extending directly behind the head along the centreline 26.

[0042] The length of each tube section 23L, 23R, 25L and 25R between the respective speaker and the user's ears (on the near side) can be any length as long as the left and right tube sections are generally the same length.

[0043] The rear tubes 25L, 25R each end with a horn (outlet) 32 on respective ear cups 40L, 40R such that the horn is behind the user's respective ear 12L, 12R and points toward the back of the ear. Each of the front tubes 23L, 23R likewise ends with a horn 32 that is placed in front of the user's ear and points toward the front of the ear.

[0044] Additional speakers 42L, 42R are provided in respective ear cups 40L, 40R for each ear. These speakers are located close to, and in front of, the ear and have the bass signal sent to them. It should be understood that the ear cups are optional in that the tubing outlets 32 and additional speakers need not be located within a closed environment, but may be open to the ambient air near the ears. However, an advantage of having enclosed ear cups is their ability to block or reduce unwanted sounds from the surroundings that would otherwise interfere with the sounds from the headset. The inside surface of the ear cups may be covered in a sound absorbing material 44 to further reduce interference from outside noise and echo within each ear cup. Each ear cup may also be perforated to reduce the echo within each ear cup. Further, each ear cup may optionally have an insert 46 (as can be seen in Figure 2) to exaggerate the front/rear distinction with a vertical panel in line with the ear pinna. Yet further, the ear cups may have ports on top and bottom to enhance air convection through the cup and avoid overheating the ears, thus enhancing comfort for extended usage.

[0045] Figure 3 shows another embodiment of the present invention with the tubes formed to meet at the front 14 and back 16 of the user's head, and extending generally in a horizontal or other plane which encompasses the ear cups 42L, 42R. This embodiment demonstrates that the tube path may be formed to any desired

shape, as long as the earlier noted distances and configurations (such as the distance "d" and the distance from the speaker to tube outlet 32) are maintained. Figure 3 also illustrates that the sound absorbing material 34 between the speakers may block the entire inside portion of the tubing and further reduce sound travel between the left and right side speakers.

[0046] Exemplary embodiments of the present invention take the sound signals that would normally be sent to a surround sound speaker system (e.g. 4 channel, 4.1, 5.1, 6.1, etc.) and accurately create the sound cues in a headset so that the user can clearly locate the direction of the sounds. For 4-channel sound, four location headset speakers (denoted earlier as 22L, 22R, 24L, 24R) should be used. For 5.1 and 6.1 sound, five and six location speakers, respectively, should be used. Two bass speakers (42L, 42R) may be used, one placed close to each ear, in any of these alternate designs. The position generating headset speakers are placed at specific locations in the tubes to create the correct perception of sound location. Humans apparently cannot tell the direction of bass sounds, so the bass speakers do not have to be located at strategic locations in the tubes, but rather can be close to the ears.

[0047] Referring now in greater detail to the acoustically sealed chamber 28, each chamber is located behind a respective position generating speaker 22L, 22R, 24L, 24R as shown in Figures 1 to 3 to improve the sound generated by the speaker. The larger the chamber, the greater the improvement of the bass sounds of the speaker. The chamber forms an enclosure whose length (i.e. perpendicular distance away from the speaker) may vary from 0.25" (6 mm) to 10" (254 mm) or longer. Each chamber has sound absorbing material 30 for reducing the echo effect within. Each chamber may be ported or can be acoustically sealed. If it is acoustically sealed, it is otherwise vented to the ambient air to allow for atmospheric pressure changes to equalize pressure between the front and the rear of the speaker. The vent 29 consists of a small hole at the far end of the chamber opposite the speaker which has a seal that prevents sound waves from passing, yet allows the slow passage or leakage of air. There are several ways to block the acoustic waves and allow the slow leakage of air. One method is to provide a thin tube mounted to the hole so that the tube creates resistance to the oscillation of air, yet allows the equalization of slowly changing air pressure. Figure 7 shows one embodiment of the rear speaker chamber with a vent which is acoustically baffled. The cavity 85 behind the speaker is baffled from vent 84 by an inner dome 82. Between the chamber wall 81 and the inner dome 82 is a layer of porous sound absorbing material 83 which damps the acoustic waves yet allows equalization of atmospheric pressure. If the chamber is ported the hole shape and size can be tuned to amplify the desired low frequencies, and no venting is required since the port allows the pressure equalization.

[0048] For present purposes, a "vented" chamber refers to a chamber which is designed to allow the air pressure to slowly equalize (say over the span of several seconds or minutes) but where the acoustic waves are largely blocked. So, acoustically it performs as if it were sealed. A "ported" chamber is a chamber that is designed with an opening that is tuned to perform a given function with the acoustic properties of the chamber. A ported chamber may appear to have a simple hole. A ported chamber may have a hole that is designed to have a diameter, length and shape along its length to perform an amplification of given frequencies while also being aerodynamically shaped to minimize the turbulence of the air (and hence the hiss) as the acoustic waves pass through the port.

[0049] Other embodiments of the invention are illustrated in Figures 4 and 5. In the headset 50 of Figure 4, a separate or distinct tube 52 is provided as a dedicated passageway from a given speaker 54 to the user's ear. This eliminates the need for the T-connections between speakers and tubes (as in the embodiments of Figures 1 to 3), but this requires two speakers for every sound source location (one ducted to the left ear and one ducted to the right ear).

[0050] In the headset 60 of Figure 5 only front tubing 62 and front location speakers 64 are provided. The sound from the omitted rear tubing and speakers is simulated by sending appropriate signals directly to the additional speakers 66 at the ears. This embodiment adopts or mimics a surround configuration where rear speakers are located beside the listener and only slightly behind the listener.

[0051] Further variations of the present invention may now be appreciated. In one variation, a speaker with a horn (similar to 32) may be placed above and/or below each user's ear and pointing towards the ear to simulate sounds from above (e.g. an airplane flying over) or below the user. Another variation may have the ends of the tubes oriented at specific angles to the ear (either in addition to or instead of being placed in front of and behind the ear) and which are coordinated with the source of sound. For instance, in systems with more than four speakers, there may be speaker outlets front and rear as well as speaker outlets for specific angles in front and rear, and in some cases with height angles (i.e. at angles above the ear). Yet another variation may have one location speaker per ear in a short tube with a horn placed in front and behind the ear. The sound timing, intensity and cross-feed would then be controlled by electronic delays and filters. This variation could provide a more compact headset and take advantage of the listener's own pinna shape to modify the sounds, but it requires electronic processing to produce the timing, intensity and cross-feed effects.

[0052] An exemplary embodiment employing electronic processing is illustrated in Figure 8, which shows the region around the left ear cup with an electronic control and two speakers per ear. The location generating speakers 122L and 124L are located in front of and be-

hind the ear 12L, respectively, and employ a rear chamber 128 similar to the other embodiments. A short length horn 132 is used in front of each speaker 122L, 124L. An electronic processor 90 receives the normal multi-channel sound signals 91, 92 from a signal source. Referring to Figure 9, which shows the wiring within the electronic processor 90, a signal 97 for the left front speaker 122L is sent to two paths, namely directly to the left front speaker 122L, through a circuit 95a to the right front speaker 122R which creates an approximate 0.5ms delay (the actual amount depends on the size of the head size that is being simulated), and through a circuit 95b to the right front speaker to modify the frequency character to simulate the blockage that the right ear experiences due to a sound from the left front position. The rear channels are modified in a similar manner with circuits 96a and 96b, but the type of frequency modification is changed since it is representing sound coming from behind the head and this is more damped due to the presence of hair at the back of the head. These modifications in frequency are documented in prior art, as is the electronic technique to implement it.

[0053] The delay time for sounds from one side depends on the size of the head. People with small head size, for example children, experience a shorter delay time than people with large head size. The delay time can be fine tuned as an adjustable feature within the electronic controls. In the method with no electronics, an adjustment can be provided by a slider joint that lengthens or shortens the distance between the left and right speakers. Figure 10 shows a detail of a slider joint 74 located in the vicinity of the sound absorbing material 34 that is placed between the right and left speakers. This slider joint is preferably included for both the front tubes and the rear tubes. In the version shown the left tube 76 of the slider joint (within which the sound absorbing material 34 is located) slides inside the right tube 75.

[0054] In yet a further variant of the invention, an equalizer is used to compensate for limitations in the speaker quality and possibly to compensate as well for limitations in the speaker enclosure, tube and horn design. Figures 11a and 11b illustrate the equalizer's effect. The desired outcome for an audio system is a relatively flat frequency output 100. However, all speakers 102 have limitations in what they can achieve and generally are unable to produce the frequencies in the lower and higher frequencies. Therefore, an equalizer 104 may be used to amplify the signal of the frequencies that the speaker has trouble with to produce the relatively flat net output 100.

[0055] Figure 6 shows yet another variation, where the body of the headset 71 (i.e. the speakers, tubes and horns) may rest stationary on the user's shoulders. The horns are adjusted to be at the same horizontal plane as the ears. The horns are in a similar position as in the other configurations. The sound sources may then be held stationary while the head is allowed to rotate. This can be either without the use of the optional ear cups 70, or if using the ear cups, the ear cups use a slider or flexible connection between the ear cup and the stationary horn outlets. The head can pivot with respect to the headset to provide a head tracking ability.

Any ambiguity in the direction of the sound source is addressed when the user's head is allowed to move and change the timing and intensity of the sound reaching the ears.

[0056] In greater detail, the headset rests in a stationary position, for example, on the user's shoulders, and the user's head can move (right or left by an amount in the range of 20 degrees) relative to the relatively fixed points of the tube ends. For example, if the user head turns to the right, the left ear goes forward, closer to the front left horn end, and the right ear goes rearward, closer to the rear right horn end. The ears also rotate so that the left ear 'opens' more to the left front horn end, and the right ear rotates slightly away from the right front horn end. This changes the sound timing, intensity and pinna effect in the same way that normal head rotation changes these directionality cues.

[0057] Further variations of the present invention are illustrated in Figures 12, 13a and 13b. As can be seen in Figure 12, the listener, through the use of an adjustable opening on the ear cup, can control the acoustic character of the sound. The opening also provides ventilation to the ear. The opening may be provided with a means to close the opening, and the means to close the opening may vary and numerous options would be apparent to a person skilled in the art. The control of the opening may be with a slider panel, a removable snap-in panel, or a series of small panels that nest in each other when the cup is to be open yet slide over each other to form a closed panel when desired.

[0058] In a further variation, shown in Figures 13a and 13b, the headphone can also comprise a tube outlet being placed near to or within the user's ear canal. This produces a quality sound effect without the need for amplification or the bass speaker. The listener benefits by having both ears hear the sound from the speaker. The compact design may consist of multiple speakers connected to the ear outlet. The tubes of each speaker may contain a degree of sound absorbing material to replicate a portion of the effect of the location of that the speaker represents. For example, speakers representing the rear channels could have sound absorbing materials between each speaker and the outlet to represent the damping effect that occurs with sounds coming from behind the head and pinna.

[0059] While particular embodiments of the present invention have been described in the foregoing, it is to be understood that other embodiments are possible within the scope of the invention and are intended to be included herein. It will be clear to any person skilled in the art that modifications of and adjustments to this invention, not shown, are possible without departing from the spirit of the invention as demonstrated through the exemplary embodiments. The invention is therefore to be considered limited solely by the scope of the appended claims.

Claims

1. A headset apparatus comprising:

   at least one first sound emission means;
   at least one second sound emission means;
   at least one first tube connected adjacent a first end thereof to the at least one first sound emission means;
   at least one second tube connected adjacent a first end thereof to the at least one second sound emission means;
   a first outlet at a second end of the at least one first tube for positioning the at least one first outlet at a first position adjacent a user ear; and
   a second outlet at a second end of the at least one second tube for positioning the at least one second outlet at a second position adjacent the user ear.

2. The headset apparatus of Claim 1 wherein the at least one first tube is continuous with the at least one second tube at respective first ends thereof.

3. The headset apparatus of one of Claims 1 to 2 wherein the first and second sound emission means are speakers.

4. The headset apparatus of one of Claims 1 to 3 wherein the at least one first tube and the at least one second tube are of substantially the same length.

5. The headset apparatus of one of Claims 1 to 4 further comprising ear engaging members for housing the first and second outlets.

6. The headset apparatus of one of Claims 1 to 5 wherein the first and second outlets each flare outwardly in a direction away from the first and second tubes respectively.

7. The headset apparatus of one of Claims 1 to 6 wherein the first and second sound emission means are each housed within a chamber.

8. The headset apparatus of Claim 7 wherein the chamber is a vented acoustically sealed chamber.

9. The headset apparatus of one of Claims 7 to 8 wherein the chamber is a ported chamber.

10. The headset apparatus of one of Claims 7 to 9 wherein the chamber is provided with sound absorbing material on a rearwardly disposed interior surface thereof.

11. The headset apparatus of one of Claims 2 to 10 wherein at least one of the first and second tubes is provided with sound absorbing material therein between a respective first end thereof and a respective first or second sound emission means.

12. The headset apparatus of Claim 11 wherein the sound absorbing material substantially blocks the at least one of the first and second tubes.

13. The headset apparatus of one of Claims 11 to 12 wherein the sound absorbing material partially blocks the at least one of the first and second tubes.

14. The headset apparatus of one of Claims 1 to 13 wherein each of the first and second outlets are provided with sound absorbing material.

15. The headset apparatus of one of Claims 1 to 14 further comprising at least one bass sound emission means adjacent the user ear.

16. The headset apparatus of Claim 15 wherein the at least one bass sound emission means is housed within an ear engaging member.

17. The headset apparatus of Claim 5 wherein the ear engaging members are provided with sound absorbing material on an inner surface thereof.

18. The headset apparatus of one of Claims 5 or 17 wherein the ear engaging members are perforated.

19. The headset apparatus of one of Claims 5, 17 or 18 wherein at least one of the ear engaging members is provided with a substantially vertical insert for positioning generally adjacent a centre of the user ear.

20. The headset apparatus of one of Claims 1 to 19 wherein the at least one first and second sound emission means and the at least one first and second tubes are positioned generally on top of a user head.

21. The headset apparatus of one of Claims 1 to 20 wherein the at least one first and second sound emission means and the at least one first and second tubes are positioned in a substantially horizontal plane generally at sides of a user head.

22. The headset apparatus of one of Claims 1 to 21 comprising two first sound emission means and two second sound emission means.

23. The headset apparatus of one of Claims 1 to 22 comprising three first sound emission means and three second sound emission means.

24. The headset apparatus of one of Claims 1 to 23 further comprising:

at least one third sound emission means and a third tube connected thereto at a first end of the third tube for positioning a second end of the third tube at a third position adjacent the user ear; and
at least one fourth sound emission means and a fourth tube connected thereto at a first end of the fourth tube for positioning a second end of the fourth tube at a fourth position adjacent the user ear.

25. The headset apparatus of one of Claims 1 to 24 wherein the at least one first tube and the at least one second tube comprise means for slidable length adjustment.

26. A headset apparatus comprising:

at least one first sound emission means;
at least one second sound emission means;
each of the at least one first and second sound emission means having at least one first tube connected adjacent a first end thereof to the respective at least one first or second sound emission means, the at least one first tube connected at a second end thereof to a first outlet for positioning the at least one first outlet at a first position adjacent a user ear;
each of the at least one first and second sound emission means having at least one second tube connected adjacent a first end thereof to the respective at least one first or second sound emission means, the at least one second tube connected at a second end thereof to a second outlet for positioning the at least one second outlet at a second position adjacent the user ear; and
electronic control means to control emissions of the at least one first and second sound emission means.

27. The headset apparatus of Claim 26 comprising two first sound emission means and two second sound emission means.

28. A headset apparatus comprising:

a sound emission means;
a tube connected adjacent a first end thereof to the sound emission means;
an outlet at a second end of the tube for positioning the outlet at a position adjacent a user ear; and
bass sound emission means adjacent the user ear.

29. The headset apparatus of Claim 28 wherein the outlet and bass sound emission means are housed within an ear engaging member.

30. A headset apparatus comprising:

at least one first sound emission means;
at least one second sound emission means;
at least one first tube connected adjacent a first end thereof to the at least one first sound emission means;
at least one second tube connected adjacent a first end thereof to the at least one second sound emission means;
a first outlet at a second end of the at least one first tube for positioning the at least one first outlet at a first position adjacent a user ear;
a second outlet at a second end of the at least one second tube for positioning the at least one second outlet at a second position adjacent the user ear; and
supporting means for supporting the headset apparatus on a user;
such that the user ear can be moved relative to the headset apparatus.

31. The headset apparatus of Claim 30 wherein the supporting means are for positioning on shoulders of the user.

32. The headset apparatus of one of Claims 30 to 31 further comprising ear engaging members for housing the first and second outlets.

33. The headset apparatus of Claim 32 further comprising adjustable connection means between the ear engaging members and the first and second outlets for enabling automatic adjustment of a connection length between the ear engaging members and the first and second outlets when the user ear is moved relative to the headset apparatus.

34. The headset apparatus of Claim 33 wherein the adjustable connection means comprise a slidably extensible connective member between the ear engaging members and the first and second outlets.

35. The headset apparatus of one of Claims 33 to 34 wherein the adjustable connection means comprise a flexibly extensible connective member between the ear engaging members and the first and second outlets.

36. A headset apparatus comprising:

a sound emission means;
a first tube connected adjacent a first end thereof to the sound emission means;
a second tube connected adjacent a first end thereof to the sound emission means;
a first outlet at a second end of the first tube for positioning the first outlet adjacent a first user

ear; and
a second outlet at a second end of the second tube for positioning the second outlet adjacent a second user ear.

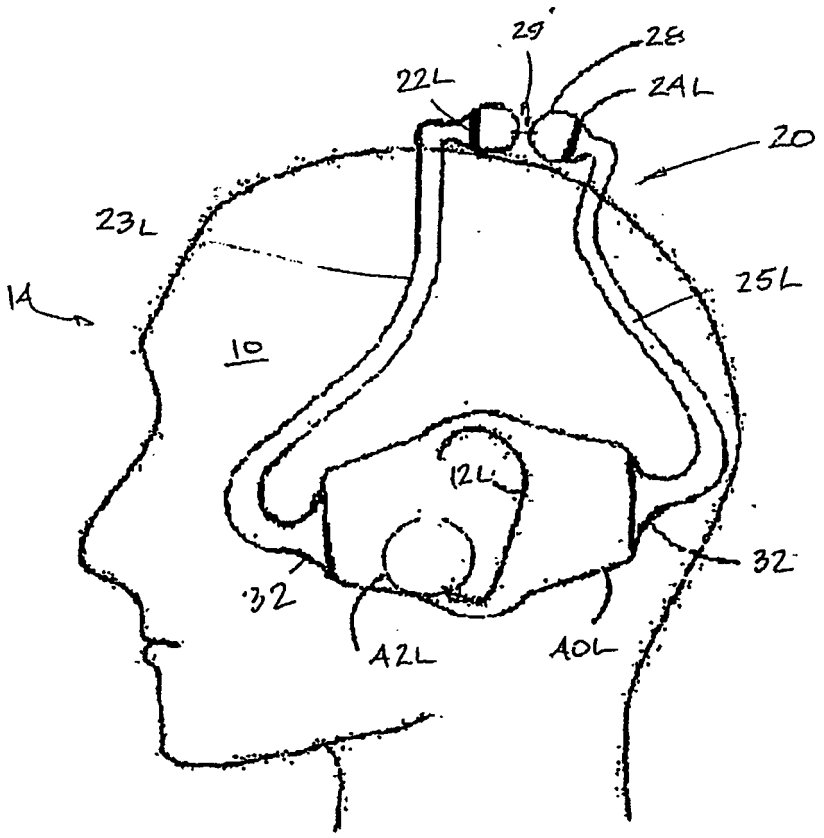
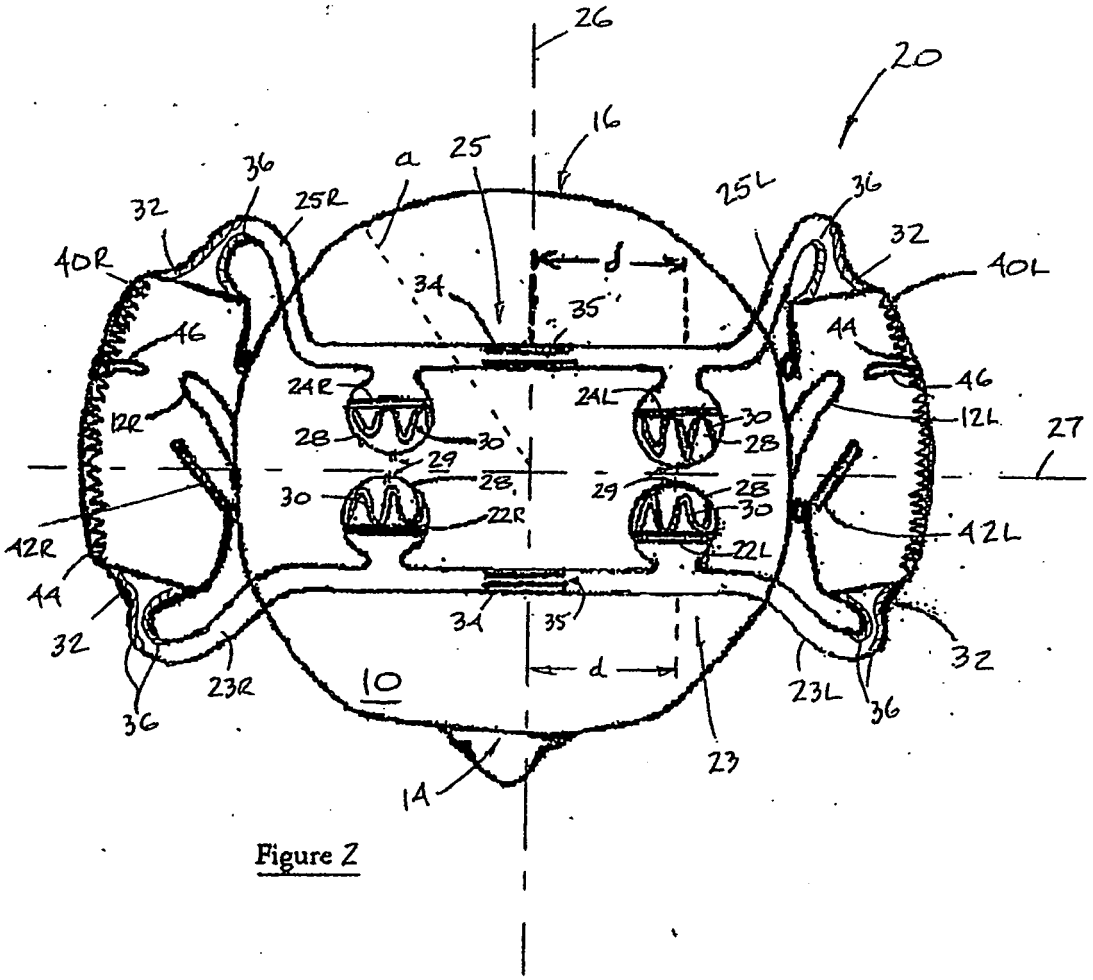


Figure 1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20
16
a
25
36
32
25R
25L
40R
40L
34
35
d
46
12R
12L
24R
24L
28
30
29
27
22R
22L
42R
42L
44
23R
23L
10
1A
23

Figure 2

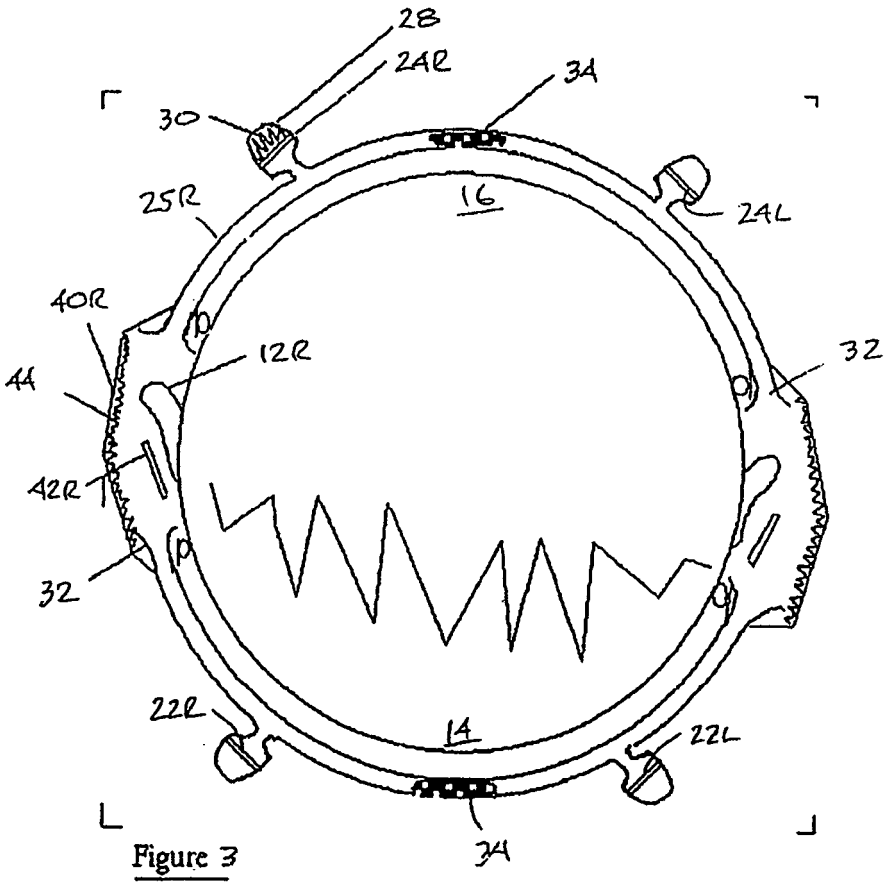

Figure 3

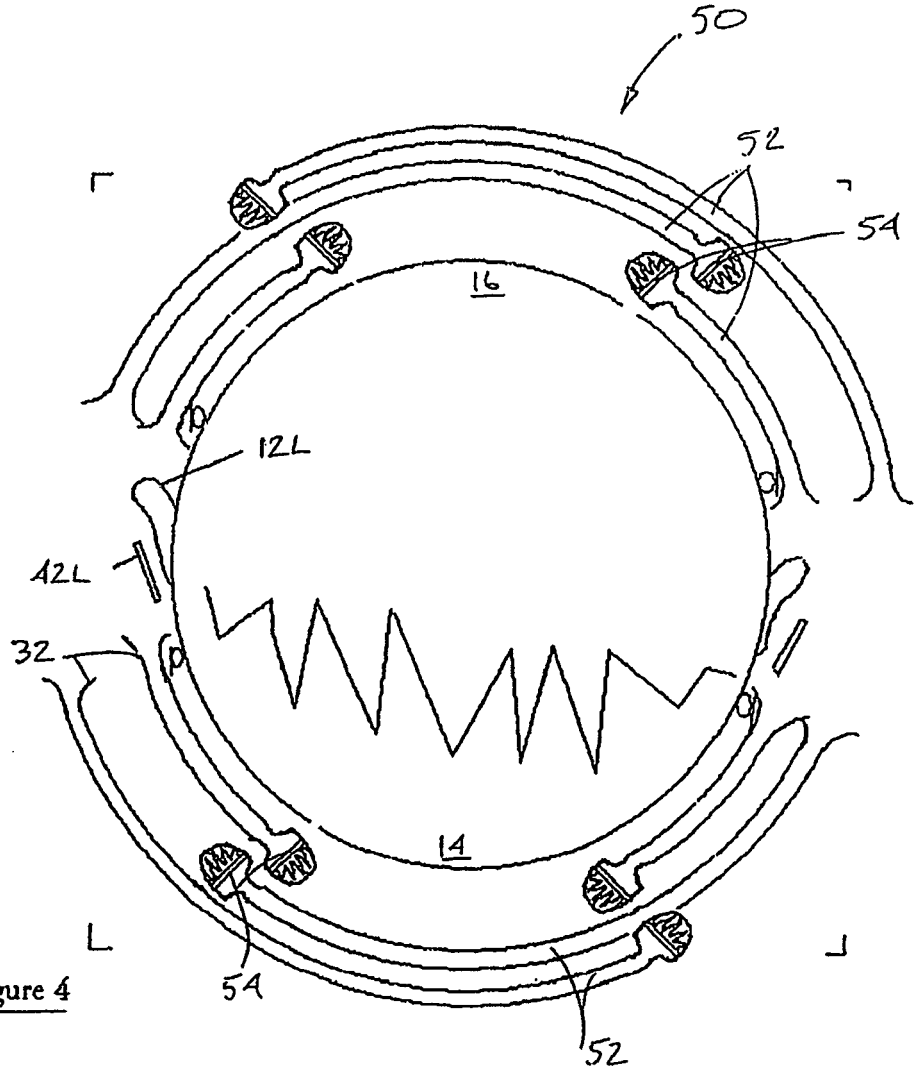

Figure 4

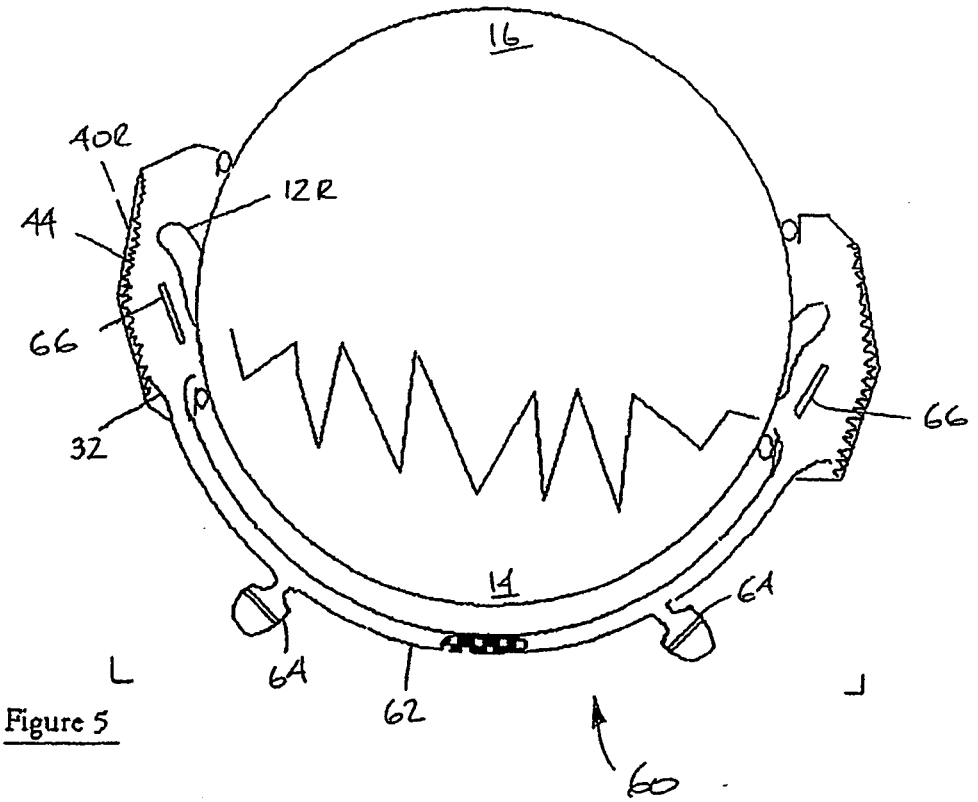

Figure 5

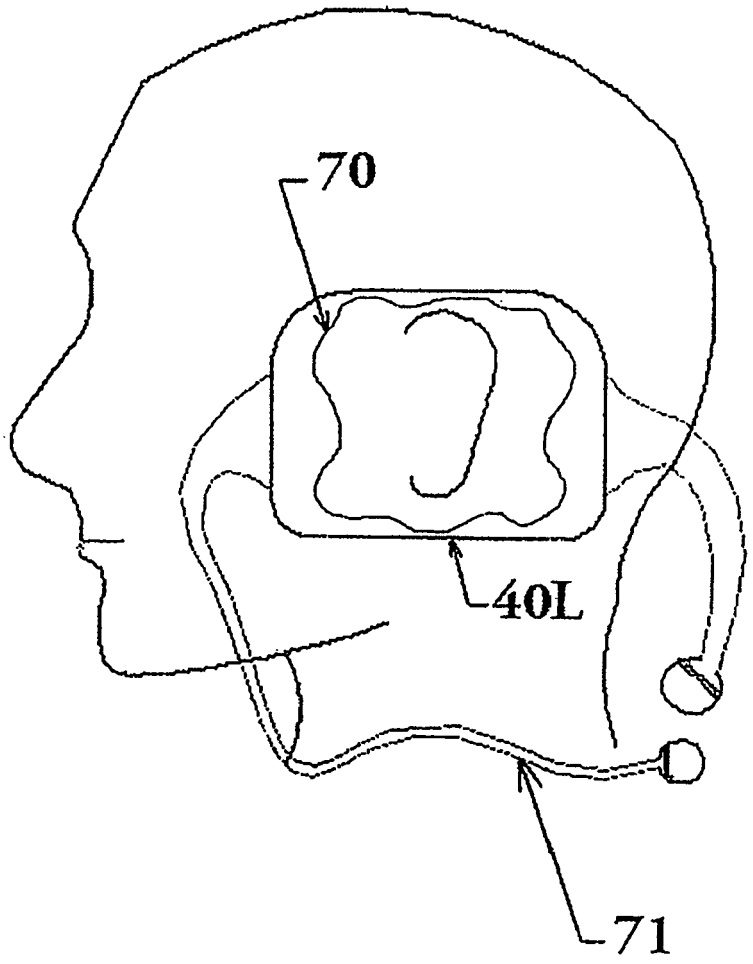

Figure 6

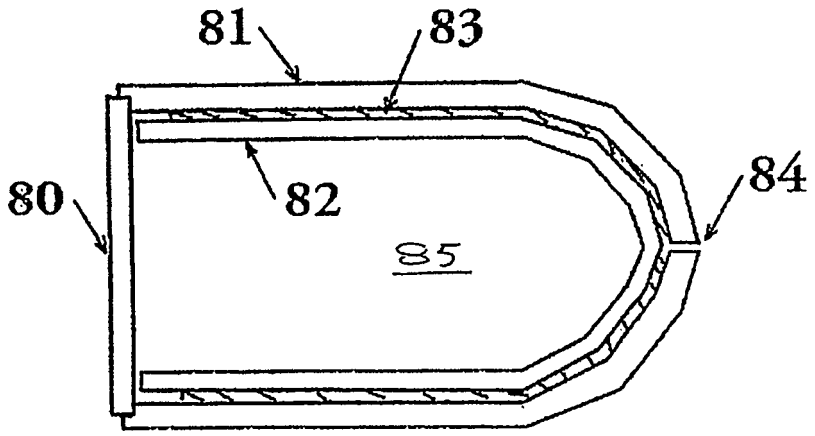

Figure 7

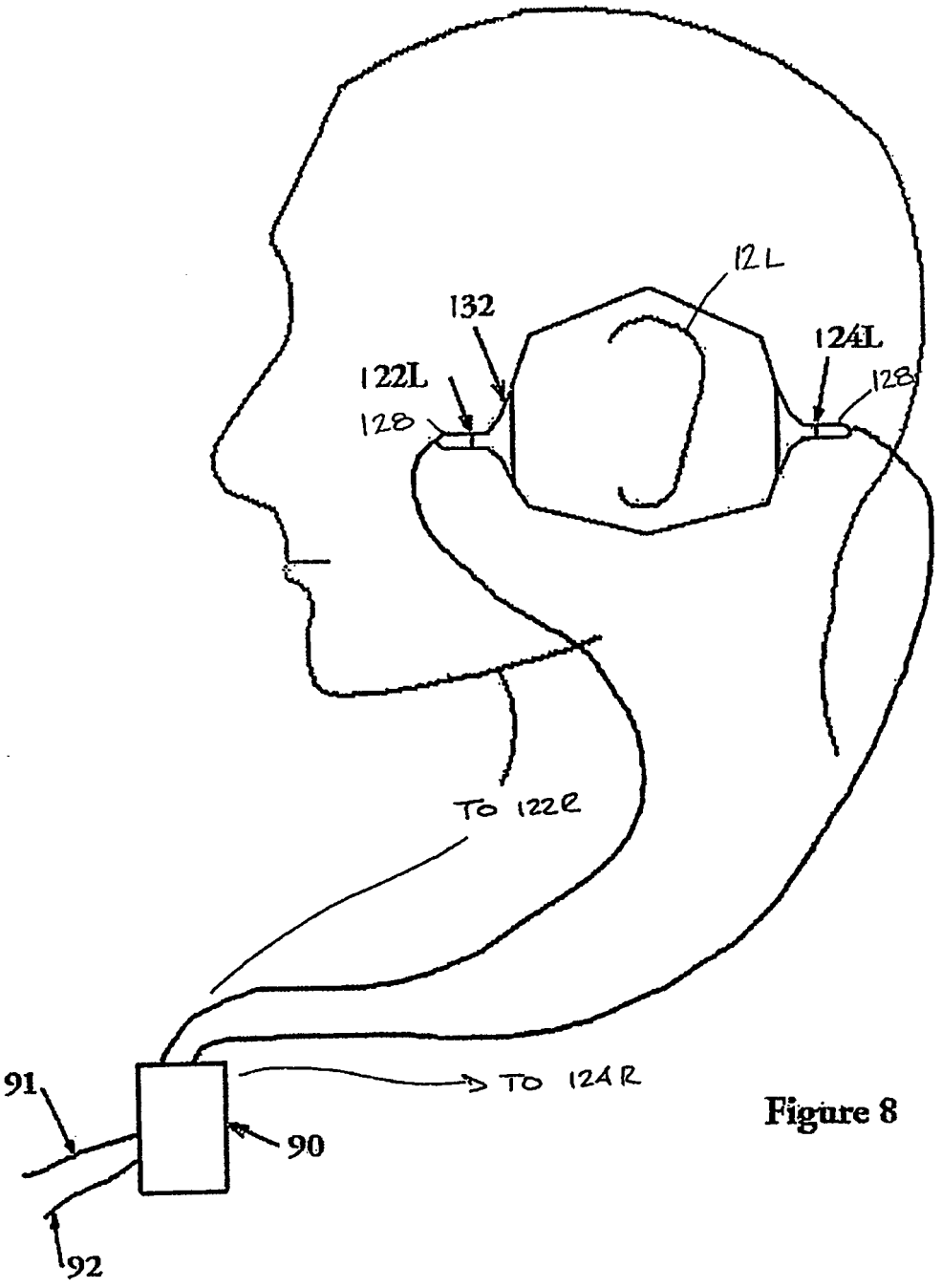

Figure 8

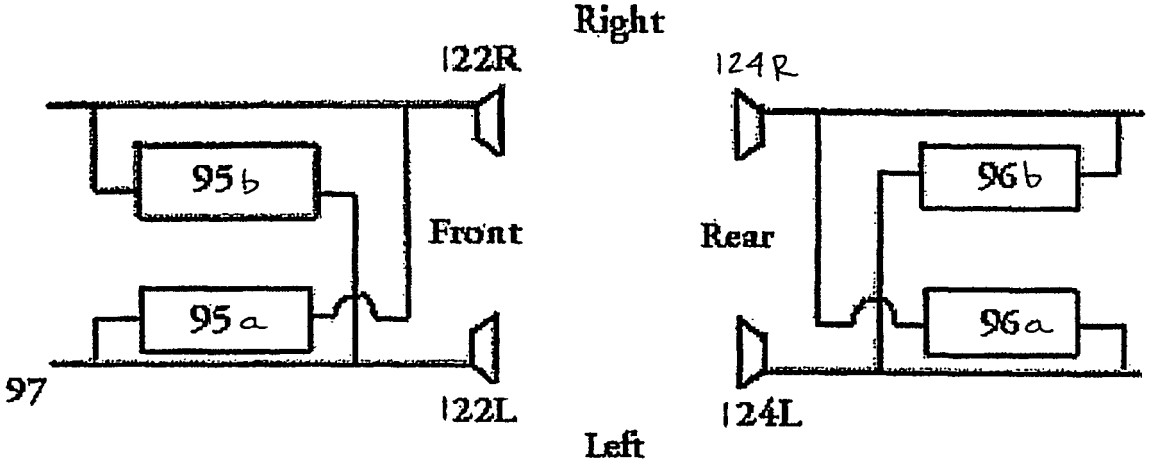

Figure 9

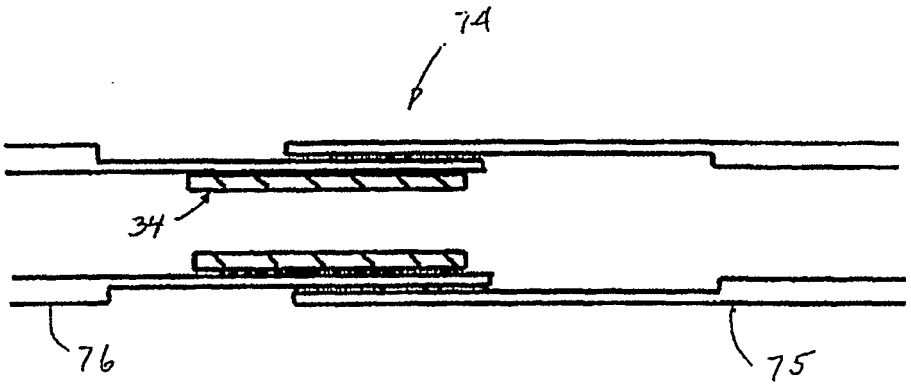

Figure 10

FIGURE 11B

Sample of using Equalization to compensate for speaker/enclosure/tube system effects

Freq	Speaker (db)	EQ/amp (db)	Net effect (db)
50	5	19	24
100	10	14	24
200	17	7	24
400	20	4	24
800	22	2	24
1600	24	0	24
3200	20	4	24
6400	15	9	24
12800	12	12	24
25600	6	18	24

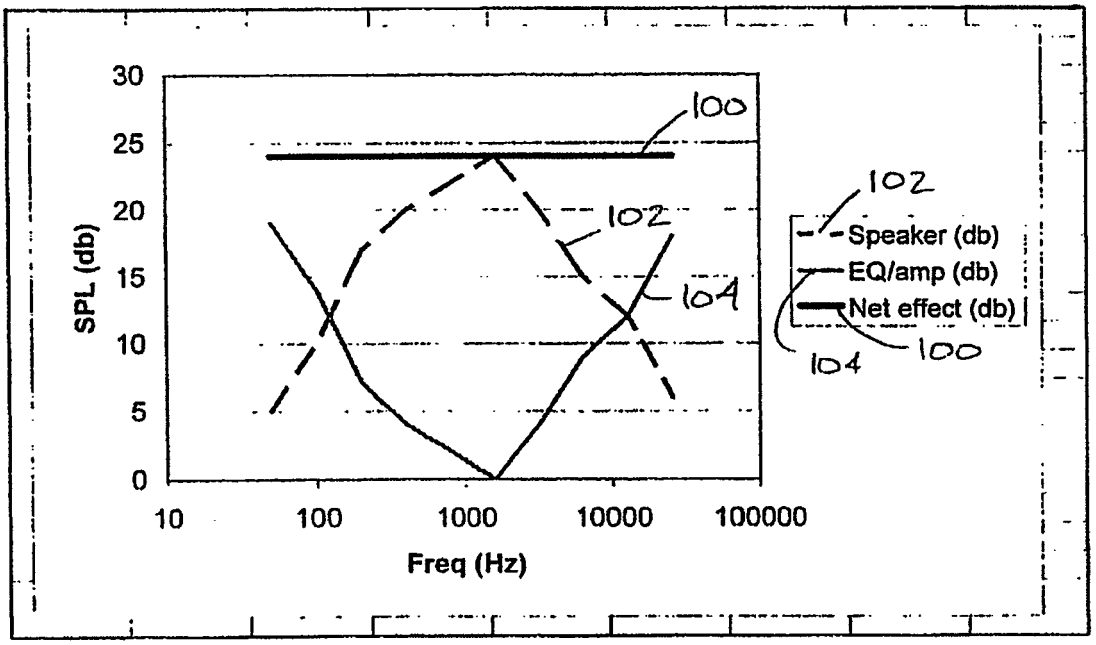

FIGURE 11A

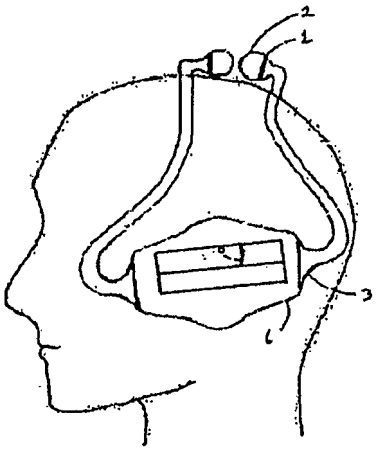

Figure 12: Adjustable ear cup opening, side view

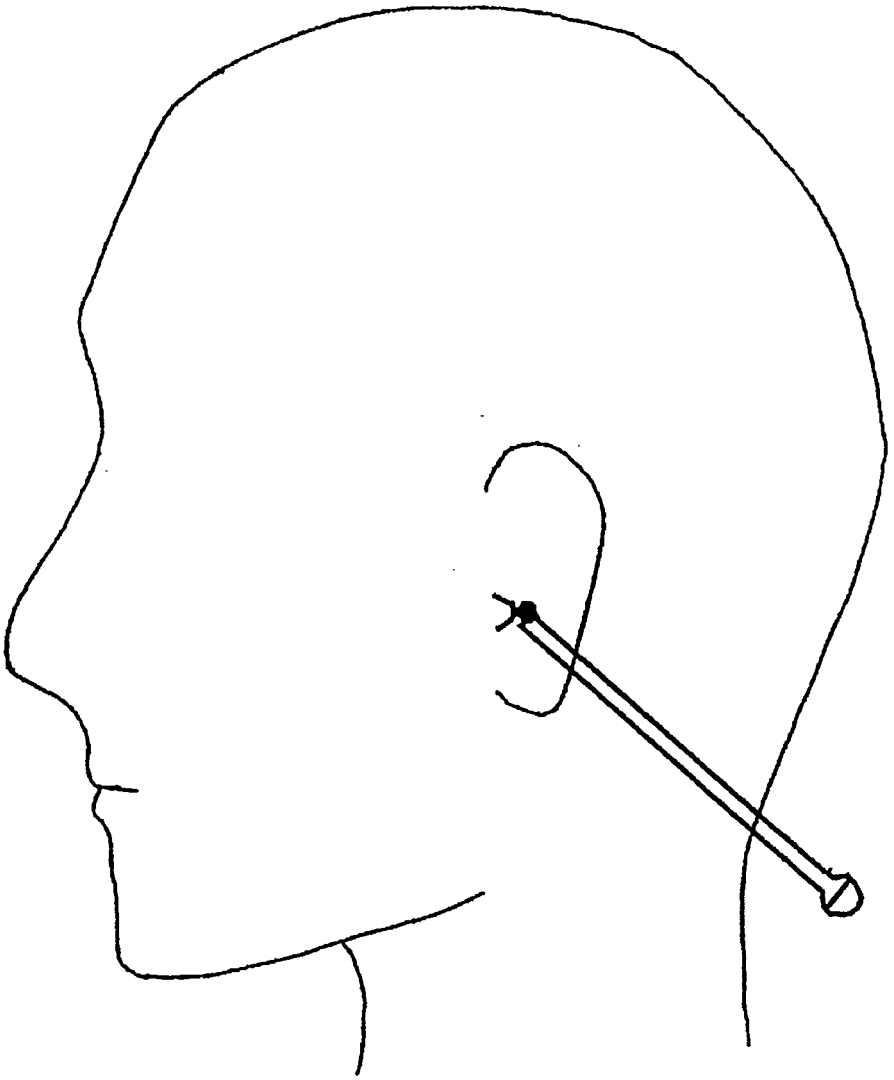

Figure 13a Small ear phone style

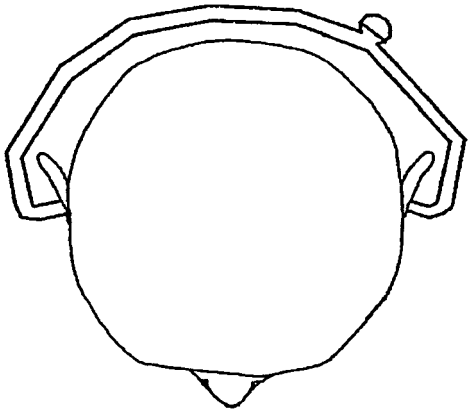

FIG. 13b

Small ear phone style, top view