A hearing aid system for providing improved and adjustable directivity.

18 Claims, 12 Drawing Figures
HEARING AID SYSTEM

BACKGROUND OF THE INVENTION

In the prior art, most hearing aids worn on the head, including aids mounted or worn behind the ear, hearing aids mounted on eyeglasses and hearing aids mounted in the ear lack satisfactory directivity.

Prior art microphones used in hearing aids commonly have non-directional response characteristics; and, people who wear hearing aids often find that the hearing aid does not give them any adequate indication as to the relative direction of the source of sound. Because of the non-directional characteristics of the hearing aid and microphone combination, a wearer may realize various problems. One example is the case where a number of persons are involved in a discussion and several of them are talking at the same time, in which case the wearer may find it difficult to detect the source of each particular sound. In contrast to the foregoing, a person wearing a hearing aid with directional characteristics is afforded the advantage of sensing the direction of the source of sound so that he may turn his head in the direction of the source; and, he can preferentially pick out or distinguish the source of that particular sound while detection of the source of sound is aided by his visual sense.

Accordingly, various efforts have heretofore been made to provide directivity in hearing aids. However, for one reason or another, such prior art devices have not been entirely satisfactory. For example, some of such prior devices are highly sensitive to noise and to undesired amplified sounds which are objectionable to the wearer. Such undesired amplified sounds which reach the microphone in the hearing aid tend to be re-amplified and produce whistling sounds which become quite annoying to the wearer.

The problem of obtaining satisfactory directional response is further complicated when a person who is hard of hearing in both ears wears a hearing aid for one ear only. Or, the degree of deafness of each ear of a wearer of a hearing aid is not equal; that is, the wearer may hear better through one ear then he can through the other ear.

Also, as is known, the human head distorts the normal sound patterns, such that a person who wears a hearing aid mounted on one side of the head hears a sound coming from that side louder or more distinctly than the sound coming from the other side of the head.

Thus, since the auditory requirements of each earer varies, it is highly desirable to provide a hearing aid with adjustable directivity enabling the user to adjust or alter the directivity to position the sound reception or rejection angle at an optimum for his use.

Accordingly, it is a principal object of the present invention to provide a hearing aid in which the directivity is adjustable for changing the direction of maximum and minimum relative sensitivity.

The foregoing and other features and advantages of the invention will be apparent from the following more particular description as illustrated in the accompanying drawings wherein:

FIG. 1 is a drawing useful in explaining the operation of the invention;

FIGS. 2(a)–2(e) show various polar pattern responses useful in explaining the inventive apparatus;

FIG. 3 is a drawing illustrating an eyeglass-mounted hearing aid useful in explaining important features of the invention;

FIGS. 4(a) and 4(b) depict the top of a human head and show a head-mounted hearing aid for purposes of explaining the response balancing concept of the invention;

FIG. 5 is an isometric view of an embodiment of the invention wherein the spacing or distance between the hearing aid housing openings is adjustable;

FIG. 6 shows a side view of the structure of FIG. 5;

FIG. 7 shows a modification of FIG. 5;

FIG. 8 shows a vertical view partially in section of a hearing aid wherein the directivity is adjusted by a vane or gate and the openings face outwardly;

FIGS. 9(a) and 9(b) are drawings useful in explaining the operation of the embodiment of FIG. 8;

FIG. 10 shows a behind-the-ear hearing aid wherein flexible tubes extend from the microphone ports outwardly to the hearing aid housing;

FIG. 11 shows a microphone wherein the size of the cavity is varied to change the directivity of the microphone; and,

FIG. 12 shows the microphone of FIG. 11 mounted in position in the hearing aid housing.

DESCRIPTION OF THE INVENTION

It should be understood at the outset that the present invention is generally applicable to hearing aids of the behind-the-ear type, in-the-ear type, the eyeglass-mounted type, and other head-worn types as will become clear hereinafter.

At this point, a brief explanation of certain theoretical considerations involved herein appears desirable. Note that in the various Figures, like reference characters refer to like elements.

It will be understood that the following explanation applies generally; the various distances, times and directions expressed are approximate and for purposes of reference; and, are not intended to be limiting in any way.

FIG. 1 depicts a head-mounted hearing aid 11, which could be of the behind-the-ear type or the eyeglass-type, see also FIGS. 3, 5 and 10. The microphone capsule 12 of the hearing aid 11, see FIG. 3, includes two physically spaced or separated sound ports, labeled A and B which correspond to ports 18 and 20 in FIG. 5. The circular arc 43 in FIG. 1 represents, at one instant of time, the location at port A of a bit of information emanating from a sound source No. 1 located in a frontal direction (approximately 0° incidence) relative to the wearer. At 0.56 inches farther away from the source No. 1, at the position of port B as indicated by the dotted circular arc 45, the same bit of information passes 41.4 microseconds later. The microphone 12 recognizes the difference as a sound signal from the preferred direction and produces a full output.

In a second case, a bit of information arrives at one instant of time from a disturbing sound source No. 2 located, in this example, in a rearward direction (approximately 180° incidence) first at port B as indicated by circular arc 47 and then approximately 41.4 microseconds later, at port A as indicated by the dotted circular arc 49. The microphone 12 recognizes this time difference as an undesired signal and produces minimal output.
Microphone 12 provides the foregoing functions by having a built-in 41.4 microsecond time delay to thereby delay the sound wave pressure that enters port B by 41.4 microseconds and cause a subtraction of the sound pressure entering port B from the sound pressure entering port A.

In the foregoing example of sound coming from source No. 1, the sound pressure at port B, which is subtracted from the sound pressure entering at port A, is effective at port A approximately 82.8 microseconds earlier. Thus, the sound pressures are not the same and these do not cancel each other, therefore an output results.

In the foregoing example of sound coming from source No. 2, the sound arrives at port A 41.4 microseconds after it entered port B. This same sound is delayed 41.4 microseconds by microphone 12 so that identical pressures are subtracted; and, hence cancel.

In order to permit substantially complete cancellation, the sound pressures entering the two ports on the microphone capsule should be equal in magnitude. Thus, the coupling between the apertures in the hearing aid 11 housing, and the sound ports A and B of the included microphone capsule 12 should affect both internal sound paths similarly. The foregoing is most effective if the coupling paths are resonant at the frequency range in which the directivity is desired.

For angles off to the side of the 0° - 180° incidence line, the time difference in traveling between port A and port B is less than 41.4 microseconds. This produces less complete cancellation.

The sound pattern pickup is shown in FIG. 2(a) for one embodiment of a microphone having an effective port spacing or separation of 0.56 inches, and is the known cardioid polar pattern. The maximum sensitivity is at 0°, one-half maximum sensitivity (−6dB) occurs at approximately 90° and there is zero sensitivity at 180°.

FIG. 2(b) shows polar pattern characteristics based on port spacing of 1.08 inches, and FIG. 2(c) shows the polar pattern characteristics based on a port spacing of 0.29 inches. The latter two spacings were chosen to provide an approximate 10 dB difference between the 0° and 180° sensitivity and can be compared to the sensitivity obtained at 0.56 inches spacing which provides the cardioid polar characteristic of FIG. 2(a).

Accordingly, a basic feature of the invention is the adjustment of the directivity of a hearing aid microphone combination to enable the wearer to adjust the received sound pattern, and the direction of minimum sensitivity.

In one form, the invention has at least two ports or access openings where the sound may reach the microphone; and, the microphone recognizes the difference in time it takes a sound wave to go between these ports. As will be described, the directivity may be adjusted by utilizing a structure which permits manipulation of the effective sound port spacing. Adjustment of the directivity may also be obtained by adjusting the communication between two sound ports and the sound inlets.

Another modification for adjusting directivity includes a microphone capsule protruding into two chambers which have adjustable spaced ports for sound entry; a compliant support is utilized to support the capsule, and the support functions as a chamber divider.

Thus, the present invention provides a hearing aid microphone combination which distinguishes between sounds coming from various directions, making the overall hearing unit a more useful product, and enhancing the acceptability of hearing aid devices. More specifically, by utilizing the inventive aid microphone combination, it is possible to recognize sound coming from a preferred direction over the echo and reverberation, and other interfering sounds, that arrive from other directions. The present invention provides desired directional characteristics, as well as minimizing feedback noises and compensating for distortion or distortion caused by the wearer's head.

Refer now to FIG. 3, which shows a hearing aid 11 for eye glasses 15 which has a directional microphone capsule 12 located in a temple piece 17 of the eye glasses. The other known components of hearing aid 11 including receiver 14 may also be mounted on temple piece 17, as is well known. As mentioned above, a person wearing the hearing aid 11 normally wants to face (visually contemplate) the source of the primary sound, on which he is interested, indicated by the arrow line 13. In accordance with the present invention, the hearing aid 11 and microphone capsule 12 provide improved and adjustable directivity to enable the wearer to distinguish the desired source of sound.

If the microphone capsule 12 is mounted so that the sound wave has free access to its sound port regions A and B of FIG. 1, such as by housing the capsule in an acoustically transparent enclosure or arranging the hearing aid structure so that the sound ports appear at the exterior of the structure, the microphone capsule 12 will exhibit the directional characteristics that are designed into the capsule.

Refer now to FIGS. 5 and 6. We have found that by mounting the microphone capsule 12 in a small recess or chamber 21 with provisions for altering the phase of the sound wave applied to the sound ports 18 and 20 (corresponding to port A and B of FIG. 1) the directional characteristics of the hearing aid all can be adjustably controlled and varied.

Recess or chamber 21 can be conveniently formed in the temple piece 17 or in the head type of hearing aid, see FIGS. 7 and 10. Recess 21 is enclosed on all sides; one side includes as the closure element a slidable element with a port, as will become clear. Microphone capsule 12 is mounted in position intermediate suitable isolator mounting pads 25, which not only mount the microphone capsule in position, but also function to effectively separate the recess 21 into two separate sound cavities 27 and 29 for purposes to be explained.

Microphone capsule 12 is electrically connected as by leads 31, as is known through an amplifier to the receiver 14 and other known components of the hearing aid 11 (similarly as indicated in FIG. 10).

A stationary panel or cover 23 positioned over cavity 27 is suitably attached to temple piece 17; and, a slidably movable panel or cover 28 is mounted over cavity 29. Panel 23 includes an opening which functions as a first or front sound inlet 24, and panel 28 includes an opening 26, which serves as a second or rear sound inlet 26. Panel 28 is movable relative to panel 23 and the purpose of such movement is control and adjustably vary the separation or spacing between openings 24 and 26. Relative to a 0° incidence line, inlet 26 is positioned rearwardly of inlet 24.

The pads 25 mount the microphone capsule 12 so that it seals any opening between the two cavities 27 and 29. The front port 18 of the microphone capsule
opens or acoustically couples into the front cavity 27 and the rear port 20 of the microphone capsule opens, or acoustically couples, into the rear cavity 29. Sound inlet 24 opens, or acoustically couples, to front cavity 27 and sound inlet 26 opens, or acoustically couples to the rear cavity 29.

Under the foregoing structure or conditions, it is the separation and placement of the sound inlets 24 and 26 coupling respectively to the cavities 27 and 29 which determine the effective port separation; and not, the physical separation of the microphone capsule ports 18 and 20 themselves. The sound inlets 24 and 26 may be single large cutouts in the temple piece 17 forming part of the hearing aid housing, or a plurality of small holes or slits in the hearing aid housing; and, may include even moderately long tubes connecting the cavity to the exterior of the hearing aid housing, as hereinafter described with reference to FIG. 10.

Since the sound openings or inlets 24 and 26 can be variably adjusted in position with respect to each other, by selectively controlling the distance between the sound openings 24 and 26, the directional response characteristics of the hearing aid 11 microphone capsule 12 combination can be adjusted and varied.

Note that for purposes of clarity of illustration, in FIGS. 5 and 6 and in other various Figures, the openings 24 and 26 are shown as facing upwardly. However, for purposes of minimizing perspiration and moisture which can enter through the openings 24 and 26 into recess 21, and for enhancing the draining of any perspiration and moisture which does get into recess 21, the openings 24 and 26 actually face downwardly. Also, for cosmetic purposes, the openings 24 and 26 may be more suitable faced downwardly.

The microphone ports 18 and 20 are sufficiently large so that the ports have minimal impendence and do not introduce resonances or phase shift which would upset the directional characteristics of the hearing aid. However, high impedance ports can be used as long as the front cavity/front port, and rear cavity/rear port combinations are balanced such that the same amplitude changes are introduced in both places.

As mentioned above, the directivity of the microphone 12 in the hearing aid 11 is controlled by the separation of inlets 24 and 26 which determine the effective port separation. In general, the cardioid polar pattern response, indicated in FIG. 2(a), is obtained for a selected port separation. As the effective port separation is increased from the selected separation, a response as indicated by the polar pattern in FIG. 2(b) will be obtained. On the other hand, as the effective port separation is decreased from the selected port separation, which provides a cardioid response and approaches zero, the sensitivity decreases; the response at 180° will no longer be zero; and, the microphone becomes essentially non-directional as indicated in FIG. 2(c).

Also, it has been found that unwanted amplified sounds, such as for example, sounds which escape from the acoustical coupling to the ear including the ear insert 16, (see FIG. 3) or, from the connections of the sound tube 18, which connects the ear insert to the hearing aid, may be coupled as an acoustical feedback and reamplified by the microphone capsule 12 thereby causing whistling or squealing sounds. Such unwanted sounds appear to come from the approximate direction indicated by the arrowed line 33 in FIG. 3.

By adjusting the directivity of the hearing aid microphone combination, a minimum response can be provided for sound coming from the approximate direction indicated by the arrowed line 33 to minimize or eliminate the whistling or squealing sounds.

The aforementioned distortion or shadow effect caused by the human head of the normal sound patterns effective on a head mounted hearing aid is depicted in FIG. 4. If, for example, microphone 12X is mounted at the position indicated in FIGS. 4(a) and 4(b), it will have a minimal sensitivity to sound coming from the approximate direction indicated by the arrow 22. Thus, adjustment of the directivity for the hearing aid 11 microphone capsule 12 combination to provide a minimum response to sound coming from the direction of the arrowed line 33 also tends to balance the minimum response to sound caused by the diffraction of the wearer's head.

Further to the foregoing discussion, since the head alters the directional response pattern it follows that the exact positioning of the hearing aid on the wearer's head also affects the directional response pattern. For example, a hearing aid could be mounted in the hair on top of the head and preferably near the forehead to provide a more symmetrical directional pattern than a hearing mounted behind the ear. In present usage, however, it is more common to use behind-the-ear, in-the-ear, and eyeglass mounted hearing aids. In any case, the invention permits the wearer or the dealer/clinician to adjust the directivity of any of the aforementioned types of head-mounted hearing aids including the in-the-ear type to provide the directivity pattern desired by the individual wearer.

As mentioned hereinafore, such adjustment will minimize feedback to minimize the noise and also permit higher acoustical gain which factor is especially critical with vented ear molds or open ear fittings; and, will determine the direction of minimum null or nulls to minimize the reception of undesired sounds from the direction which a specific user finds most objectionable.

Further, such adjustment permits a single hearing aid to adjust the sound pattern response nulls such that the most symmetrical pattern about the medium plane of the hearing aid is obtained. FIG. 2(a) shows the cardioid response pattern of a directional hearing aid itself while FIG. 2(d) shows approximately the normal response of such a hearing aid when it is mounted on a user's head. Note that the response pattern is rotated approximately 45° and the null is not sharp.

Referring to FIG. 2(c), for a head-worn hearing aid, two significant minima occur in the region of approximately 125°-145° and 215°-235°. This hearing aid when mounted on the head which has a diffraction pattern as illustrated in FIG. 2(d) combines to provide the sensitivity pattern shown in FIG. 2(e). Thus, there are a number of variations in response patterns. However, the invention provides the feature that whatever the variations in the sound pattern, the wearer or the dealer/clinician can empirically adjust the directivity of the hearing aid microphone combination to obtain the optimum response desired by the wearer.

It should also be understood from the above that while cardioid response aligned on the θ axis is indicated as desirable when the user wants minimum response from a single direction, variations thereof can
be obtained by the proper inlet and port positioning and orientation.

A second embodiment of the invention is shown in FIG. 7, which illustrates a portion of a behind the ear type of hearing aid. The structure of FIG. 7 is generally similar to that of the embodiment of FIGS. 5 and 6. In FIG. 7, the microphone capsule 12 is mounted by means of the mounting pads 25 in recess 21. The cover 23A for the recess 21 extends the full length of the recess and includes a series of spaced holes or apertures functioning as sound openings, generally labeled as 30. Plugs or screws or any suitable obstructions 32 are selectively placed in holes 30 such that only selected ones of the holes 30 remain open, to thereby adjustably change the spacing or separation between the sound access opening, or inlets to the respective cavities 27 and 29, and thence to the microphone capsule 12 and the sound ports 18 and 20.

FIG. 8 shows another embodiment of the invention which provides means for controlling the phase of the sound wave arriving at the sound port regions 18 and 20 of the microphone capsule 12, see also FIGS. 9(a) and 9(b). The microphone capsule 12 is mounted in a recess 21 on a suitable mounting pad 25A. Pad 25A is placed as a bottom and side support for capsule 12, and, a passageway 41 remains open along the length of the capsule to acoustically connect the left and right hand regions 21A and 21B of recess 21.

Refer now also to FIGS. 9(a) and 9(b) for a brief explanation of the operation of the structure of FIG. 8. When vane 43 is fully opened, as shown in FIG. 9(a), the phase of the sound wave arriving at the microphone capsule 12, indicated by the direction of the arrowed line 13 represents a distance D1 as shown in FIG. 9(a). When the vane 43 is closed, the effective phase of the arriving sound wave is represented by the distance D2 in FIG. 9(b). Intermediate settings of the vane 43 produce intermediate phase shifts and intermediate directional characteristics of the hearing aid microphone combination.

More specifically, a change in the position of vane 43 of FIG. 8 produces a change in directional sensitivity, similarly as does varying the relative spacing between the sound inlets 24 and 26 of FIGS. 5 and 6. Refer again to the polar pattern curves of FIG. 2. FIG. 2(c) for example, indicates the condition when vane 43 is in the open position shown in FIG. 9(a); that is the microphone capsule 12 has a sensitivity pattern which is only slightly directional. As the vane 43 is moved from its open position to its closed position shown in FIG. 9(b), the directional sensitivity gradually changes to the pattern shown in FIG. 2(b).

Refer again to FIGS. 5 and 6 as well as to FIG. 4. As mentioned, the hearing aid 11 microphone capsule 12 combination can be adjusted to have a null or minimal sensitivity to sound coming from any desired direction. Thus, by selectively adjusting the effective port separation (and the vane position of FIG. 8), a minimal sensitivity can be obtained for sound coming from the direction of arrowed line 23 in FIG. 4. An advantage of such adjustment, as mentioned above, is that the unwanted sounds which cause the aforementioned whistling can be effectively rejected, and, also the over-all hearing aid can be operated at a higher amplification level for receiving the desired sounds. An additional advantage is that the response pattern can be balanced such that the minimal sensitivity or response to sound coming, say from the direction indicated by arrowed line 23, can be substantially balanced with the lowered sensitivity or response to sound coming from the direction indicated by arrowed line 21 (due to the aforementioned diffraction provided by the wearer's head), while maintaining maximum sensitivity to sound coming from a frontal or 0° incidence direction.

The embodiment of the invention shown in FIG. 10 comprises a microphone capsule 12A generally similar to microphone capsule 12 of FIG. 5 which is mounted in a chamber 51 of a behind-the-ear type hearing aid 11. FIG. 10 also shows, as small blocks, usual hearing aid components including the amplifier, receiver and battery which are suitably connected as is well known in the art. Hearing aid 11 includes a first or forward sound opening 53 which communicates through a flexible, extensible tubing 54 directly to port 18A of microphone 12A. A flexible tubing 59 couples to rear sound port 20A. The free end of tubing 59 forms a second or rear opening 57 facing in an upward direction and turned approximately 90° relatively to opening 53.

An acoustically transparent cover 64 is mounted to shield the openings 57 and the outwardly extending tube 59 to minimize wind noise; and, also to enhance the cosmetic appearance of the hearing aid.

The forward sound opening 53 is positioned such when the hearing aid is mounted on the wearer's head the 0° incidence line 13 extends substantially straight ahead of the wearer. Also, the tube 59 is adjustably pivotable about the rear opening 57 to provide mechanical adjustment of the spacing between the openings 53 and 57.

The embodiment of the invention shown in FIG. 11 comprises a microphone capsule 12B mounted similarly as shown in FIGS. 5, 6 and 7. In this embodiment, the adjustment of directivity of the hearing aid microphone housing combination is provided by including an adjustable phase shifting means in the microphone capsule itself.

The front port 18 of the microphone capsule 12B is similar to port 18 of FIGS. 5 and 6. The directivity of the hearing aid housing microphone capsule combination is varied by an adjustable piston or plate 63 which is mounted as by resilient bellows 68 onto the interior of the microphone capsule case 62. A set screw 70 protrudes out of the capsule case, and is adjustable to move the plate 63 into the microphone cavity 60 to vary the size of the cavity. The adjustment of the acoustical volume of the cavity controls the phase shift or delay and thus controls the directivity of the hearing aid microphone combination.

The barometric pressure affects the phase shift produced by an acoustical impedance and a cavity; accordingly FIG. 11 shows a hearing aid microphone combination which is essentially independent of barometric pressure by providing pressure sensitive bellows 64 and 65 which mount a plate 67 which changes the area or size of the opening of the rear sound port 20B. As the barometric pressure increases, the bellows contract to tend to restrict the port 20B and a higher acoustical impedance. Conversely, as the barometric pressure decreases, the bellows expand to increase the effective port 20B thereby to reduce the acoustical impedance.

While the invention has been particularly shown and described with preferred embodiments thereof, it will be understood by those skilled in the art that various
changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A hearing aid including a housing, a directional microphone in said housing, said microphone having at least two spaced sound ports, said housing having at least two spaced sound openings, means for acoustically coupling said sound openings to respective ones of said sound ports, and means for adjusting the effective acoustical delay between said sound ports for determining the directivity of said hearing aid.

2. A hearing aid as in claim 1 wherein said sound openings and sound ports are in longitudinal spaced relation to form relative front and rear openings and front and rear sound ports, and means are provided for varying the separation between said sound openings.

3. A hearing aid as in claim 2 further including an acoustical chamber in said housing, means for mounting said microphone in said chamber to separate said chamber into a front cavity and a rear cavity, the front sound opening communicating with the front cavity and the front sound port; and, the rear sound opening communicating with the rear cavity and the rear sound port.

4. A hearing aid as in claim 2 wherein said microphone is mounted to provide a front cavity region and a back cavity region in said chamber, a passageway connecting said front and rear cavity regions, and means for selectively restricting said passageway whereby said chamber acoustically changes from functioning as a single cavity to functioning as two separate cavities thereby to determine the directional characteristics of the hearing aid.

5. A hearing aid as in claim 4 wherein said means for selectively restricting said passageway is a vane mounted in said passageway, said vane being rotatable from a first or open position to a second or closed position to restrict and close said opening.

6. A hearing aid as in claim 4 further including means attached to said vane and extending outwardly of the hearing aid housing for manually selecting the position of the said vane.

7. A hearing aid including an acoustical chamber in said housing, a microphone mounted in said housing, said microphone having an acoustical cavity and having relative front and rear sound ports coupling to the cavity, said housing having spaced sound openings in relative front and rear positions, said rear sound port providing an acoustical phase shift, and means for adjusting the effective acoustical phase shift thereof to thereby determine the directivity of said hearing aid.

8. A hearing aid as in claim 7 wherein said microphone includes a plurality of sound ports, and means for selectively closing said sound ports to determine the directivity of the hearing aid.

9. A hearing aid as in claim 7 wherein means are provided for mounting said microphone in said chamber, and means for changing the volume of the microphone cavity to change the directivity of said hearing aid.

10. A hearing aid as in claim 7 wherein said means for adjustably changing the acoustical phase shift comprises means for changing the size of said opening responsive inversely to the barometric pressure.

11. A hearing aid as in claim 9 further including a plate, bellows means positioning said plate adjacent said rear opening, said bellows means being responsive to barometric pressure to thereby change the position of said plate relative to said rear port to thereby change the acoustical impedance of said rear port.

12. A hearing aid as in claim 9 further including a plate mounted in said cavity, said plate connected to a movable member, resilient expandable affixed to said cavity and expandable as said plate is moved in said cavity, said member being manually positionable to vary the position of said plate in said cavity and hence the effective size of said cavity to thereby vary the directivity of the hearing aid.

13. A hearing aid including a housing having an acoustical chamber therein, a directional microphone mounted in said chamber, said microphone having at least two spaced sound ports, said housing having at least two spaced sound openings, means for acoustically and selectively coupling said sound ports to said sound ports, and means for varying the spacing between the sound openings to provide an effective acoustical spacing different from the spacing between said sound ports to thereby vary the directivity of the hearing aid.

14. A hearing aid as in claim 13 wherein the orientation of the minimal response sensitivity of the hearing aid may be determined by the orientation and relative separation of the sound openings.

15. A hearing aid as in claim 13 further including a first tube connecting one of said openings to one of said sound ports and a second tubing for connecting the other of said openings to the other of said sound ports.

16. A hearing aid as in claim 15 wherein a first opening faces a frontal direction and a second opening faces in an upward direction, and means for adjusting the position of said second tubing to thereby adjustably vary the distance between the two openings.

17. A hearing aid as in claim 13 wherein said microphone is mounted in said chamber to form a front and a rear cavity, means for adjusting the separation between the openings to thereby determine the directivity of said hearing aid.

18. A hearing aid as in claim 13 including a series of longitudinally spaced openings, and means for selectively closing said openings to vary the directivity of said hearing aid.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,770,911
DATED : November 6, 1973
INVENTOR(S) : Hugh Shaler Knowles et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 9, "A." should read --A--.
Column 5, line 10, "effectice" should read --effective--.
Column 5, line 67, "dircetion" should read --direction--.
Column 9, claim 7, line 44, after "including" insert --a housing having--.
Column 9, claim 4, line 26, "2" should read --3--.
Column 9, claim 6, line 40, "4" should read --5--.
Column 10, claim 10, line 8, delete "opening" and insert --rear sound port--.
Column 10, claim 12, line 18, after "movable" delete "member" and after "expandable" insert --member--.
Column 10, claim 12, line 19, after "and" insert --said member being--.

Signed and Sealed this
twenty-first Day of October 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

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Commissioner of Patents and Trademarks
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,770,911 Dated November 6, 1973

Inventor(s) Hugh Shaler Knowles et al.

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Column 5, line 10, "effective" should read -- effective --.

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Column 9, claim 7, line 41, after "including" insert
-- a housing having --.

Column 10, claim 12, lines 18 and 19, after "movable"
delete "member" and after "expandable" insert -- member --.

Signed and sealed this 4th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR. C. MARSHALL DANN
Attesting Officer Commissioner of Patents