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**Datasheet for the decision  
of 17 October 2024**

**Case Number:** T 0448/22 - 3.5.05

**Application Number:** 16172087.5

**Publication Number:** 3086567

**IPC:** H04R1/10

**Language of the proceedings:** EN

**Title of invention:**

IN-EAR ACTIVE NOISE REDUCTION EARPHONE

**Patent Proprietor:**

Bose Corporation

**Opponent:**

K/S HIMPP

**Headword:**

Acoustic impedance below upper bound/BOSE

**Relevant legal provisions:**

EPC Art. 56

**Keyword:**

Inventive step - all claim requests (no)



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Case Number: T 0448/22 - 3.5.05

**D E C I S I O N**  
**of Technical Board of Appeal 3.5.05**  
**of 17 October 2024**

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**Decision under appeal:** **Decision of the Opposition Division of the  
European Patent Office posted on 16 December  
2021 revoking European patent No. 3086567  
pursuant to Article 101(3)(b) EPC.**

**Composition of the Board:**

**Chair** J. Eraso Helguera  
**Members:** K. Peirs  
R. Romandini

## Summary of Facts and Submissions

I. The appeal lies from the decision of the opposition division to revoke the opposed patent (Articles 101(2) and 101(3)(b) EPC). The opposition division deemed that none of the claim requests on which the appealed decision is based complied with Articles 56, 76(1) or 84 EPC. The appealed decision had regard to the following prior-art document:

**D1:** US 2009/0161885 A1.

II. Oral proceedings before the board were held on 17 October 2024. The parties' final requests were as follows:

- The appellant (patent proprietor) requested that the decision under appeal be set aside and that the opposition be rejected, i.e. that the patent be maintained as granted (**main request**). In the alternative, it requested that the patent be maintained in amended form on the basis of one of sixteen auxiliary requests, whereby **auxiliary requests 1, 2, 4 to 6, 8, 10 and 12 to 14** are identical to those underlying the appealed decision; **auxiliary requests 3A, 3B, 4A, 7A, 9A, and 11A** were filed for the first time with the statement setting out the grounds of appeal.
- The respondent (opponent) requested that the appeal be dismissed.

At the end of the oral proceedings, the board's decision was announced.

III. Claim 1 of the **main request** reads as follows (board's feature labelling):

- (a) "Apparatus comprising:  
an earphone for an active noise reduction (ANR) earphone, comprising:
- (b) structure for engaging an outer ear so that the earphone is positioned and retained in an ear of a user;
- (c) a nozzle (70) providing a passageway that is adapted to acoustically seal the earphone with an ear canal (75) of the user at the transition between the bowl of a concha of the user and the entrance to the ear canal to form a cavity;
- (d) active noise reduction circuitry comprising a feedback microphone (11) adapted to be acoustically coupled to the ear canal, for detecting noise in the earphone;
- (e) feedback circuitry (71) responsive to the feedback microphone for providing a feedback noise canceling audio signal; and
- (f) an acoustic driver (17) for transducing an output noise canceling audio signal comprising the feedback noise canceling audio signal to noise canceling acoustic energy; and
- (g) wherein the nozzle is arranged such as to control an acoustic impedance of the nozzle,
- (h) by choosing a cross sectional area of the nozzle, a ratio of the nozzle length to the nozzle cross sectional area, and an acoustic mass of the nozzle,
- (i) in such a way as to cause an absolute value of the acoustic impedance of the nozzle to be both  
below  $8 \times 10^5 \frac{kg}{m^4 \times sec}$  at 100 Hz and  
below  $8 \times 10^6 \frac{kg}{m^4 \times sec}$  at 1 kHz."

IV. Claim 1 of **auxiliary request 1** differs from claim 1 of the main request in that it comprises, at the end, the following feature (board's feature labelling):

(j) ", wherein the nozzle has an open cross sectional area of at least  $7.5 \text{ mm}^2$ ".

V. Claim 1 of **auxiliary request 2** differs from claim 1 of auxiliary request 1 in that

- it comprises, between features (i) and (j), the following feature (board's feature labelling):

(k) ", wherein the nozzle has a ratio  $l/A$  of  $1000 \text{ m/m}^2$  or less, wherein  $A$  is the open cross sectional area of the passageway and  $l$  is the length of the passageway"

and in that

- it comprises, at the end, the following feature (board's feature labelling):

(l) ", and  
wherein the passageway has an acoustic mass  $M$  of  $1200 \text{ kg/m}^4$  or less, where  $M = (\rho l)/A$ ,  $\rho$  is the density of air,  $A$  is the open cross sectional area of the passageway and  $l$  is the length of the passageway".

VI. Claim 1 of **auxiliary request 3A** differs from claim 1 of auxiliary request 2 in that it comprises, at the end, the following feature (board's feature labelling):

(m) ", and  
wherein the acoustic driver is oriented so that a

line parallel to, or coincident with, an axis of the acoustic driver and that intersects a centerline of the passageway intersects the centerline of the passageway so that all angles formed by the intersection are  $> 45$  degrees".

VII. Claim 1 of **auxiliary request 3B** differs from claim 1 of auxiliary request 3A in that it comprises, at the end, the following feature (board's feature labelling):

(n) ", wherein the feedback microphone is radially positioned intermediate a point at which a diaphragm of the acoustic driver is attached to a voice coil of the acoustic driver and an edge of the diaphragm".

VIII. Claim 1 of **auxiliary request 4** differs from claim 1 of auxiliary request 2 in that it comprises, at the end, the following feature (board's feature labelling):

(o) ", and wherein the earphone is configured so that a portion of the acoustic driver is within the concha of the ear of the user and another portion of the acoustic driver is outside the concha when the earphone is in position".

IX. Claim 1 of **auxiliary request 4A** differs from claim 1 of auxiliary request 4 in that it comprises, at the end, the following features (board's feature labelling):

(p) "wherein the acoustic driver is oriented so that a line parallel to, or coincident with, an axis of the acoustic driver and that intersects a centerline of the passageway intersects the centerline of the passageway at angle  $\theta > \pm 30$

degrees",

(q) ", and

wherein the acoustic driver has a nominal diameter of greater than 10 mm".

X. Claim 1 of **auxiliary request 5** differs from claim 1 of auxiliary request 4 in that the word "and" is removed at the beginning of feature (o) and in that it comprises, at the end, the following feature (board's feature labelling):

(r) ", and

wherein the nozzle comprises a frusto-conically shaped structure for engaging the area of transition between the ear canal and the bowl of the concha and acoustically sealing the ear canal with the nozzle".

XI. Claim 1 of **auxiliary request 6** differs from claim 1 of the main request in that it comprises, at the end, the following feature (board's feature labelling):

(s) ", wherein the nozzle has an open cross sectional area of at least 10 mm<sup>2</sup>".

XII. Claim 1 of **auxiliary request 7A** differs from claim 1 of the main request in that it comprises, at the end and in this order, features (s) and (m).

XIII. Claim 1 of **auxiliary request 8** differs from claim 1 of auxiliary request 6 in that it comprises, at the end, feature (o).

XIV. Claim 1 of **auxiliary request 9A** differs from claim 1 of the main request in that

- it comprises, at the end and in this order, features (s), (o) and (r), with the word "and" removed at the beginning of feature (o),
- it comprises, immediately after feature (a), the following feature (board's feature labelling)

(t) "an acoustic driver module (114);"

and in that

- feature (b) was replaced by the following feature (board's feature labelling; the board also underlined amendments vis-à-vis feature (b)):
  - (u) "structure for engaging an outer ear so that the earphone is positioned and retained in an ear of a user including an outer leg (122) and an inner leg (124) extending from the acoustic driver module (114) and having joined ends, wherein the outer leg is curved to generally follow the curve of the anti-helix wall at the rear of the concha;".

XV. Claim 1 of **auxiliary request 10** differs from claim 1 of the main request in that it comprises, at the end, feature (k).

XVI. Claim 1 of **auxiliary request 11A** differs from claim 1 of the main request in that it comprises, at the end, feature (m) with the word "and" at the beginning of this feature removed.

XVII. Claim 1 of **auxiliary request 12** differs from claim 1 of the main request in that it comprises, at the end, feature (o) with the word "and" at the beginning of this feature removed.

XVIII. Claim 1 of **auxiliary request 13** differs from claim 1 of the main request in that it comprises, at the end, the following feature (board's feature labelling):

(v) ", wherein the absolute value of the acoustic impedance is defined as  $|Z| = \omega M$ , wherein M is the acoustic mass of the nozzle and  $\omega$  is the angular frequency".

XIX. Claim 1 of **auxiliary request 14** differs from claim 1 of the main request in that it comprises, at the end, feature (l), with the word "and" removed at the beginning of this feature.

## **Reasons for the Decision**

### 1. *Technical background*

1.1 The opposed patent pertains to active noise cancellation (ANR) in earphones.

1.2 Figures 5, 6 and 7A (reproduced below) of the opposed patent illustrate an embodiment with in-ear earphone 110 comprising a frusto-conical sealing structure 48. Legs 122 and 124 generally follow the curve of the anti-helix wall at the rear of the concha and keep earphone 110 in ear canal 75 while in use. This structure ensures both a comfortable fit and effective passive noise isolation.

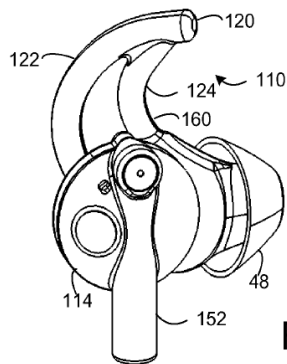


Fig. 5

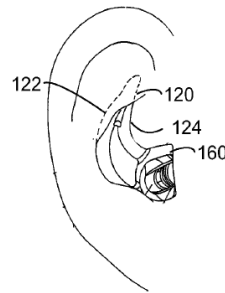


Fig. 6

Earphone 110 houses an acoustic driver 17 and a nozzle 70. The nozzle forms an acoustic passageway, coupling the acoustic driver to the ear canal. This sealed system, comprising sealed portion 77 of the ear canal, space 73 in front of the acoustic driver's diaphragm, and the nozzle, constitutes the "front cavity", i.e. "the acoustic volume that acoustically couples the acoustic driver and the eardrum" (cf. paragraph [0025] of the opposed patent). As described in paragraphs [0028] and [0034] of the opposed patent, a poorly defined "front cavity" can lead to instability in active noise cancellation, underscoring its importance in ANR earphone operation.

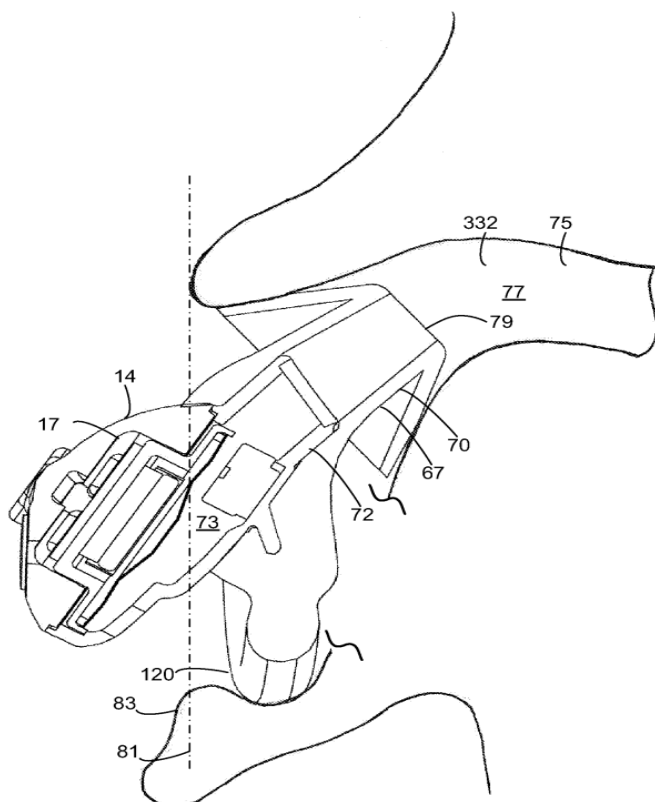


Fig. 7A

2. *Main request: claim 1 - novelty and inventive step*

2.1 In Reasons 3.2 of the appealed decision, **D1** was considered to be a suitable starting point to assess inventive step. Regarding the features of the main request, only **feature (i)** was deemed not to be disclosed in this document.

The board concurs with this assessment. In particular, it acknowledges that the diameter of the ear canal in which the apparatus disclosed in D1 is to be inserted constitutes a "practical upper limit" for the diameters of pipe 15A and of central aperture 21 shown in Figure 4 of D1. However, this "practical upper limit" only corresponds to a lower bound for the acoustic impedance instead of an upper bound as required by feature (i).

While the acoustic impedance associated with the configuration shown in Figure 4 of D1 may fall within the open-ended ranges of feature (i), it is not guaranteed to do so. Therefore, feature (i) is not directly and unambiguously disclosed in document D1 and the subject-matter of claim 1 is novel over D1 (Article 54 EPC).

- 2.2 Concerning the technical effect which feature (i) would bring about, the appellant argued, based on lines 55 to 57 of column 17 of the opposed patent, that it enabled "a significant improvement in active noise attenuation without significantly reducing the passive attenuation".

The board is not satisfied that feature (i) credibly achieves this technical effect over the whole scope claimed. The reasons for this are as follows:

- 2.2.1 First, granted claim 1 does not mention any reference against which the alleged "significant improvement" can be verified.
- 2.2.2 Moreover, the board observes that the "acoustic impedance" in accordance with feature (i) is meant to serve as an indicator of the nozzle's influence on the air flow in response to an incident acoustic wave. This influence will provide a major contribution to the "passive attenuation" of this acoustic wave, especially for higher frequencies. In contrast, the "active noise attenuation" addressed by the appellant will typically depend on a variety of parameters. One of these parameters is the "front cavity" (cf. point 1.2 above). The impact of this "front cavity" on the operation of noise-reduction earphones is explained in paragraphs [0028] and [0034] of the opposed patent. These

paragraphs clarify that the "passageway" provided by the nozzle is not the only factor to consider: the entire transfer function involved in the "front cavity", i.e. from the acoustic driver to the eardrum, must be well defined to avoid feedback-loop instability. This means that not only the nozzle (item "70" in Figure 7A of the opposed patent) but also the "sealed portion" (item "77" in that Figure 7A) of the ear canal and the space (item "73" in that Figure 7A) in front of the acoustic driver's diaphragm play a role. Moreover, the "active noise attenuation" is influenced by other parameters besides this "front cavity", such as the frequency range and position of the "noise microphone" involved.

- 2.2.3 The appellant acknowledged that factors other than the acoustic impedance of the nozzle influence the active attenuation. Nonetheless, it maintained that, when keeping the other influencing factors equal, "a relatively low impedance leads to an improvement in active attenuation by the ANR as described in the patent". The appellant drew a parallel with a person's health being influenced by many factors. It argued that quitting smoking has a "direct and causal beneficial impact on the person's health", irrespective of whether the person started several unhealthy habits at the same time.

However, the board notes that granted claim 1 does not concern "other influencing factors". Without considering these additional factors, there is at least no direct link between the "acoustic impedance" referred to in feature (i) and any "improvement" of the ANR as considered by the appellant, at least not over the whole scope claimed. Adopting the appellant's parallel, similar to a person being worse off by

picking up unhealthy habits when quitting smoking, the active noise properties of the claimed apparatus might actually worsen when adopting the acoustic impedance values of feature (i), for instance because of a change in the "front cavity" or the frequency range and position of the "noise microphone".

- 2.2.4 The appellant also referred to Figure 18 of the opposed patent, emphasising its teaching that passive attenuation can be relied upon for high frequencies while ANR is required for low frequencies. In the appellant's view, this figure showed that the invention does not sacrifice passive attenuation by going for ANR.

However, in the board's opinion, this figure merely illustrates that employing "shunt 80 necessitates a tradeoff between passive noise attenuation and active noise attenuation" (cf. the first sentence of paragraph [0056] of the opposed patent). None of the features of granted claim 1 comprises such a shunt. Moreover, nothing in granted claim 1 points at applying passive and active noise attenuation in different frequency ranges. Therefore, the respondent is right that Figure 18 of the opposed patent is irrelevant for the technical effect considered by the appellant in view of feature (i).

- 2.3 Instead, the board holds that the ranges mentioned in feature (i) only represent practical choices for the "acoustic impedance" for two frequencies in the audible range. These practical choices ultimately define the ratio between the nozzle's length  $l$  and its open cross-sectional area  $A$ , when adopting the relationship set out in paragraphs [0006], [0009], [0012], [0014] and [0015] of the opposed patent that acoustic

impedance  $M$  is given by  $\rho l/A$  (" $\rho$ " being the density of air, which is about  $1.2 \text{ kg/m}^3$  at standard temperature and pressure conditions, cf. also e.g. paragraph [0009] of the opposed patent). The board notes in this respect that paragraph [0076] of D1 recites values for the "pipe diameter" (to exceed 1.8 mm) and the "pipe length" (being between 4 and 9.8 mm). However, these values, taken by themselves, do not immediately allow to derive a value for the acoustic impedance. This is because the diameter of central aperture 21 and the precise way in which the total length of 4 mm to 9.8 mm is distributed over the constituting lengths of pipe 15A and of central aperture 21 are not mentioned in D1. The board disregards in this respect the erroneous values for the "acoustic inductance" mentioned in paragraph [0076] of D1.

- 2.4 The objective technical problem associated with feature (i), starting from D1, can therefore be framed as "how to determine practical values for the diameter and length of central aperture 21 as well as for the length of pipe 15A as shown in Figure 4 of D1".
- 2.5 In relation to obviousness, the board holds that the skilled person, using their common general knowledge, would have immediately understood that Figure 4 of D1, though schematic, offers some guidance for solving the objective technical problem posed. To analyse this in more detail, it is noted that a human ear canal typically measures 6 to 7 mm in diameter. Taking into account that eartip 20 of Figure 4 requires some space even when inserted into the ear canal, the skilled person would have considered a value between 3.5 and 4.0 mm, e.g. 3.8 mm, to be a practical value for the diameter of central aperture 21 shown in Figure 4 of D1. The diameter of pipe 15A seems to be about half of

that of central aperture 21, i.e. about 1.9 mm (exceeding 1.8 mm as required in paragraph [0076] of D1). As to the length of pipe 15A and central aperture 21, a rough estimate based on Figure 4 of D1 would be that each takes up half of the total length of between 4 and 9.8 mm prescribed in paragraph [0076] of D1, i.e. a respective length between 2 and 4.9 mm. Similar to what is set out in the last paragraph of Reasons 3.8 of the appealed decision, upper and lower bounds can now be calculated for the acoustic mass and acoustic impedance associated with pipe 15A and central aperture 21:

- 2.5.1 The upper bound can be found based on a tube having a uniform diameter being the smaller one (i.e. 1.9 mm) of the diameter of pipe 15A and central aperture 21 and with a length which is the maximum total length of 9.8 mm as specified in paragraph [0076] of D1. Assuming a circular cross-section, the equation " $M = \rho l / A$ " referred to in point 2.3 above yields an acoustic mass  $M$  of around 4150 kg/m<sup>4</sup>.
- 2.5.2 The lower bound can be found based on a tube having a uniform diameter being the larger one (i.e. 3.8 mm) of the diameter of pipe 15A and central aperture 21 and with a length which is the minimum total length of 4 mm as specified in paragraph [0076] of D1. The associated acoustic mass  $M$  is about 425 kg/m<sup>4</sup>.
- 2.5.3 To calculate the associated "acoustic impedance", Reasons 3.8 of the appealed decision states that "[a]ccording to the opposed patent, the acoustic impedance of a passageway having a uniform cross-sectional area along its length is given by  $|z| = M2\pi f = \rho (l/A) 2\pi f$ ". While this formula for determining  $|z|$  is in line with **feature (v)** defined in

point XVIII above, paragraphs [0006], [0009] and [0014] of the opposed patent only mention the equation " $|z|=Mf$ " in this context, with " $|z|$ " being the "mass impedance" and " $f$ " being "the frequency [of the acoustic wave passing through the nozzle]". Given that the open-ended ranges cited in paragraphs [0006] and [0009] of the opposed patent for the "mass impedance" are the same as those cited for the "acoustic impedance" mentioned in the opposed patent's paragraph [0004] and granted claim 1, the board will assume that the opposed patent uses the terms "mass impedance" and "acoustic impedance" as synonyms, although, as apparent from paragraph [0039] of the opposed patent, the former is but one (dominant) "component" of the latter.

The appellant asserted that the repeated occurrence of the allegedly erroneous formula in paragraphs [0006], [0009] and [0014] of the opposed patent was merely an "obvious error". However, the respondent effectively countered this assertion by highlighting the improbability of the same error being replicated in three distinct instances within the opposed patent.

Summarising, based on the values which the skilled person would have determined to solve the objective technical problem posed, the following values apply as an upper and lower bound for the acoustic impedance of the nozzle formed by pipe 15A and central aperture 21 as shown in Figure 4 of D1:

	l (mm)	d (mm)	z  (10 <sup>5</sup> kg/(m <sup>4</sup> s)) at 100 Hz	z  (10 <sup>6</sup> kg/(m <sup>4</sup> s)) at 1000 Hz
lower bound	4	3.8	0.4	0.4
upper bound	9.8	1.9	4	4

This means that the skilled person would have arrived at values for the acoustic impedance that lie within the open-ended ranges indicated in feature (i) without

performing any inventive activity.

- 2.6 The appellant insisted that the formula recited in Reasons 3.2 of the appealed decision, i.e.  $|z| = M2\pi f$ , was the only established way to calculate the acoustic impedance. It referred to two "standard textbooks" in this context.

While, in the board's view, these two "standard textbooks" indeed appear to support the definition recited in the sentence bridging columns 17 and 18 of the opposed patent, they do not confirm that this definition would be the only one that is "generally accepted" in the art of earphones. The same applies for the appellant's assertion that the "acoustic impedance is a clearly defined parameter". In fact, as set out in point 2.5.3 above, the opposed patent itself is dubious about the term "acoustic impedance", using sometimes the term "mass impedance" instead, and suggesting at least two ways to calculate it.

- 2.7 Even if one were to adhere to the formula recited in Reasons 3.2 of the appealed decision, the values mentioned in point 2.5.3 above would simply be scaled with a factor " $2\pi$ ", leading to "2.5" and "25" as respective values for the resulting lower and upper bound for the acoustic impedance. These scaled lower and upper bounds define ranges that still overlap with the ones mentioned in feature (i). The board does not agree with the appellant that, to arrive at the overlap, "it is required to select a relatively large diameter for the pipe, at or close to the maximum diameter of 3.8 mm used by the Board in combination with a fairly short pipe length at or close to the minimum pipe length of 4 mm". The respondent correctly highlighted in this regard that, for a pipe as shown in

Figure 4 of D1 with a diameter of 3.0 mm and a total length of 7.0 mm and using the formula  $|z| = M2\pi f$ , an acoustic impedance value within the range as per feature (i) results, namely of " $7.47 \times 10^6 \text{ kg/m}^4$  (at 1kHz)". The board considers the value for the diameter of "3.0 mm" adopted by the respondent to be a technically viable one, which the skilled person would have readily considered in the context of D1. This value represents, in fact, almost an average, "exceeding approximately 1.8 mm" as required in paragraph [0076] of D1, and nevertheless being below "4.0 mm", which the board considered in point 2.5 above to be a reasonable upper value for the diameter of central aperture 21 shown in Figure 4 of D1. Likewise, the respondent's choice of "7.0 mm" for the total pipe length is in the middle of the range "4 mm to 9.8 mm" mentioned in paragraph [0076] of D1.

The appellant brought further arguments in this respect, which could not sway the board either:

- 2.7.1 The appellant highlighted the distinction between over-the-ear and in-the-ear earphones and their underlying "different design paradigms", emphasising the need for high acoustic impedance specifically in in-the-ear designs to maintain a reliable feedback loop and minimise the influence of individual ear-canal variations.

The board agrees, however, with the respondent in that there is no evidence or proof of the alleged prejudice that the acoustic impedance must be "high" for in-the-ear earpieces, whatever the qualifier "high" may mean in this context. The respondent rightfully pointed out that feature (i) is the only distinguishing feature over D1. This means that it is not apparent that the

claimed apparatus would differ from the in-the-ear hearing device of D1 by more than this feature.

- 2.7.2 The appellant argued that the specific design of D1, including the earseal attachment and the oval shape of the ear canal, restricted the pipe diameter and thus favoured higher impedance. In its view, achieving larger inner diameters for pipe 15A, as suggested by the board, was impractical with D1's design. It highlighted in particular the "open loop frequency response" addressed in paragraph [0074] of D1 and shown in that document's Figures 14A and 14B. In its view, this paragraph taught that the dimensions of the outlet 15 and the aperture 21 must be chosen such that the stability of the system was improved. The appellant explained that the last sentence of paragraph [0076] of D1 considered the particularly selected frequency of 500 Hz in the "open loop frequency response" as addressed in paragraph [0074], in which paragraph also a Helmholtz resonator at 800 Hz is considered, which can be varied over a broad range from 500 to 2000 Hz. The appellant said that the Helmholtz resonator becomes stiffer at the lower end of this range, meaning that the acoustic impedance gets higher.

With this, the appellant introduced, next to the "acoustic impedance" and "mass impedance" (cf. point 2.5.3 above) mentioned in the opposed patent, yet another parameter, namely the "stiffness". In the context of a Helmholtz resonator, the board recalls that "stiffness" refers to the resistance of the air within the resonator to *compression*. A stiffer resonator implies that it takes more pressure to change the volume of the air cavity. By contrast, "acoustic impedance" is the opposition to the *flow* of sound waves. Because a higher stiffness contributes to a

greater opposition to the flow of sound waves, a stiffer resonator will generally exhibit higher acoustic impedance at its resonant frequency. However, this does not necessarily translate to D1 favouring a higher impedance. The reasons for this are as follows:

- D1 primarily aims to ensure the stability of the ANR system, particularly by controlling the phase and gain within the feedback loop inherent to the ANR system. The Helmholtz resonator, formed by the housing outlet passageway and the ear canal, helps achieve this by providing phase advance and gain control around its resonant frequency (cf. paragraph [0074] of D1).
  
- While "stiffness" contributes to "acoustic impedance", it is not the sole determinant. In the latter, other factors like the mass of the air in the neck of the resonator and resistance to airflow also play a role. D1 does not explicitly aim for maximum stiffness or impedance. Instead, it focuses on tuning the resonator to achieve the desired phase and gain characteristics for stability (cf. the previous dash). In this respect, the "open loop frequency response" referred to by the appellant is crucial for analysing the stability and performance of the ANR system. It essentially characterises the inherent behaviour of the system before the ANR control signal is applied. By understanding the system's natural response at "different frequencies", the ANR system can be tailored to achieve the desired noise attenuation profile and avoid instability. Therefore, it is reasonable to assume that the skilled person, as suggested by the appellant, would have considered the "open loop frequency response" when modifying D1, but this

does not invalidate the board's analysis in point 2.5.3 above. The skilled person, utilising their understanding of a human ear canal's typical dimensions and the need for a secure fit to determine practical values for the diameter and length of the central aperture 21 and pipe 15A, would have understood the "open loop frequency response" to represent an additional guidance in solving the objective technical problem defined in point 2.4 above. Moreover, regarding the range of possible "different frequencies", the board agrees with the respondent that the range "from 500 Hz to 2 kHz" referred to in paragraph [0074] of D1 is a mere example and that the skilled reader would readily consider other values outside that range.

- D1 provides at least some guidance as to the use of "different geometries" for the housing outlet passageway (cf. the last paragraph of point 2.7.4 below). This implies that various combinations of pipe length and diameter, and hence varying degrees of stiffness and impedance, can be employed to achieve the desired acoustic response and stability.

2.7.3 The appellant also argued that the prior art, including D1, did not consider the spectral content of the noise, while the invention specifically addresses this aspect by balancing passive and active noise reduction based on frequency.

However, as the respondent correctly pointed out, none of this is reflected in features (a) to (i).

2.7.4 The appellant contended that the board introduced new technical information not found in D1 by suggesting an

upper limit for the pipe diameter. By doing so, the board had inadmissibly supplemented the "unclear teaching" of paragraph [0076] of D1. It argued that D1's design, with the earseal attached to the outlet, necessitated a pipe diameter close to the stated lower limit of 1.8 mm to ensure proper retention and seal. It further argued that, for the type of design of D1, parameters such as the form and extent of the earseal 20 as well as the size of the undercut at the base of outlet 15 where the earseal 20 is fitted - shown in Figure 4 of D1 - are interrelated. In the appellant's view, this made it difficult to go for larger diameters of inner pipe 15A. The appellant particularly noted that the earseal shown in Figure 4 of D1 is of the "mushroom type" which needed more space than, for instance, a "shark-fin" structure. The typical oval shape of a human ear canal further supported this constraint. It concluded that the diameter of inner pipe 15A must necessarily be "considerably smaller than the diameter of the central aperture 21 of the rubber earseal 20".

However, the board maintains that the requirement in paragraph [0076] D1 of "exceeding approximately 1.8 mm" would not have not restricted the skilled person to values close to 1.8 mm (cf. Reasons 3.6 of the appealed decision). It is the board's responsibility to interpret prior-art documents from the perspective of a skilled person in the field. This involves considering both explicit details and what a skilled person would reasonably have inferred based on their common general knowledge. For the case in hand, the board holds that, when reading D1, their common knowledge of the dimensions of a human ear canal and the need for a proper seal would inevitably have prompted the skilled person to introduce a practical upper limit for the

pipe diameter. The board also agrees with the respondent that the skilled person would have understood that the undercut in Figure 4 of D1 can be adjusted to accommodate larger pipe diameters, possibly modifying the shape of outlet 15 to provide a more secure grip on the earseal with a smaller undercut. Alternatively, the skilled person could also have used a thinner or more flexible material for the earseal to reduce its bulk and allow for a smaller retention structure.

While acknowledging that the passages cited by the respondent in paragraphs [0076] (e.g. "[t]he ANR component 22 has been designed to function with a variety of different pipe lengths and diameters for the housing outlet passage"), [0077] and [0078] of D1, suggesting that the ANR component in D1 can function with various pipe lengths and diameters, do not explicitly *encourage* the consideration of different geometries, the board holds that these passages would have at least *guided* the skilled person to adjust dimensions when solving the objective technical problem. As set out in point 2.5 above, to do so, the skilled person would have identified the relevant parameters from Figure 4 of D1 (in particular the relationship between pipe length and diameter), considered practical limitations (such as the need for a secure fit of the earpiece in the ear canal and the manufacturing constraints related to the pipe diameter) and ultimately selected practical values for the dimensions of aperture 21 and pipe 15A. The board demonstrated in point 2.5.3 above that these practical values lead to an acoustic impedance that meets the requirements of claim 1.

2.7.5 The appellant agreed that the values mentioned for the "acoustic inductance" in paragraph [0076] of D1 were inaccurate, but argued that these values nonetheless pointed at a narrower range (a factor of two between upper and lower bound) compared to the values calculated in point 2.5.3 above (a factor of ten).

However, the respondent correctly pointed out that deriving a precise range from potentially incorrect values was speculative and that the accuracy of the stated values in D1 remained debatable.

2.7.6 The appellant further argued that the fixed 1:1 length ratio between the first part of pipe 15A and its remainder determined the other parameters of outlet 15, specifically highlighting the relationship between the total pipe length and the inner pipe diameter as depicted in Figure 4 of D1. It further emphasised that this ratio might not be maintained when altering the pipe length, although "because of geometric reasons" a nearly constant length would be necessary for outlet 15.

Yet, the board disagrees that this ratio determines all other parameters. Paragraph [0076] of D1 clearly allows for variation in both pipe diameter and length. Furthermore, the board notes that, while the "4.5 times" relationship highlighted by the appellant is valid for specific values within the disclosed ranges, other less extreme combinations are also possible. Moreover, maintaining the 1:1 ratio could be beneficial for acoustic consistency or manufacturing simplicity, even with reduced pipe length.

2.7.7 The appellant further pointed at a potential ambiguity in the interpretation of "pipe diameter" in D1. It

argued that the inconsistency in how the terms "pipe length" and "pipe diameter" were defined creates uncertainty, potentially impacting the assessment of inventive step.

In the board's view, the skilled reader would readily understand that the "pipe diameter for the earphone housing 10 [exceeding approximately 1.8 mm]" refers to the diameter of pipe 15A because this is the only "pipe" that is referred to as such in D1. This means that the skilled reader would interpret the phrase "a pipe diameter for the earphone housing 10 exceeding approximately 1.8 mm" as indicating a minimum pipe diameter for inner pipe 15A.

2.8 Hence, the subject-matter of granted claim 1 does not involve an inventive step (Article 56 EPC).

3. *Auxiliary requests 1, 2, 4 to 6, 8, 10 and 12 to 14: claim 1 - inventive step*

3.1 None of **features (j) to (l), (o), (r), (s) and (v)** provides a remedy for the lack of inventive-step objection raised with respect to the main request in point 2 above.

In particular, the following is noted:

3.1.1 Regarding **features (j) to (l) and (s)**, a diameter of central aperture 21 shown in Figure 4 of **D1** of 3.8 mm as mentioned in point 2.5 above leads to an open cross-sectional area of more than 11 mm<sup>2</sup>. This, in addition with a central-aperture length (or even a total nozzle length) of 4 mm, leads to a ratio " $l/A$ " of around 350 m/m<sup>2</sup> and an acoustic mass of about

420 kg/m<sup>4</sup>.

- 3.1.2 The skilled person would have arrived at the respective arrangement specified in **features (o) and (r)** as a matter of routine design based on what is disclosed in Figure 4 of D1. The frusto-conically shaped structure mentioned in feature (r) does not credibly achieve the "advantageous technical effect in comfortably stabilizing the earphone", contrary to what was alleged by the appellant with reference to column 16, lines 15 to 24 of the opposed patent. This is because feature (r) is silent about the material used for the "frusto-conically shaped structure". It could be made from a hard plastic. A hard plastic may provide a basic acoustic seal and retention function, but it is not always comfortable in the ear canal, given that the skin there is sensitive and easily irritated. The board notes in this respect that feature (r) does not preclude the necessity of mounting a protective cushion before the user puts the nozzle in their ear. Such a protective cover can then, besides providing for a comfortable wear of the earphone, also augment the hard plastic's acoustic seal and retaining function, similar to what is explained in paragraphs [0030] and [0031] of the opposed patent. The frusto-conically shaped structure according to feature (r) need not be "conformable", as opposed to the frusto-conically shaped structure comprised by sealing structure 48 as described in paragraph [0036] of the opposed patent. Nor does it need to comprise a compliant section like the one bearing reference numeral "67" in Figure 7A of the opposed patent.
- 3.1.3 Irrespective of its concerns regarding Article 123(2) EPC even when considering the term "reactive or mass component  $j\omega M$ " mentioned in paragraph [0057] of the

original description underlying the opposed patent, the board notes that, as set out in point 2.7 above, the definition for the "acoustic impedance" as stipulated in **feature (v)** simply scales the values mentioned in point 2.5.3 above with a factor " $2\pi$ ", leading to "2.5" and "25" as respective values for the resulting lower and upper bound for the acoustic impedance. Hence, there is still an overlap with the open-ended ranges mentioned in feature (i).

- 3.2 The board disagrees with the appellant's interpretation that **features (j) and (s)** of claim 1 require a homogenous minimum diameter throughout the nozzle's length. These features merely stipulate a minimum open cross-sectional area at some point within the nozzle, achievable with a diameter of approximately 3.6 mm. This value falls within the practical range for the central aperture 21, as discussed in point 2.5 above. Moreover, it yields, assuming nonetheless a homogeneous cross-sectional area of the nozzle over its length and using the formula in feature (v), an acoustic impedance of  $5.2 \times 10^5 \text{ kg}/(\text{m}^4 \times \text{sec})$  at 100 Hz.

While the appellant argued that this diameter would necessitate abandoning the two-part pipe design, the board considers that less drastic modifications, such as adjusting the undercut, modifying the outlet shape or using a different earseal material (cf. point 2.7.4 above), are adequate. The board is not even convinced that the skilled person would have needed to make such modifications, given that, as correctly emphasised by the respondent, the ultimate limit is determined by the size of the human ear canal (approximately 6 to 7 mm), which comfortably accommodates a 3.6 mm diameter.

3.3 Regarding **feature (o)**, the appellant argued that it allowed for larger devices with the transducer positioned partially outside the concha, unlike D1, which taught that the transducer must be positioned inside the concha. The appellant emphasised that D1 lacked a structural anchor and relied solely on a seal, while claim 1 of auxiliary request 4 permitted longer devices extending outside the concha. The appellant further noted that introducing a larger transducer in D1 created stability issues due to weight changes, highlighting this as a technical advantage of the invention.

The board notes that, while paragraph [0048] of D1 describes a concha-fitting housing in Figure 3, it also indicates that the housing can take various shapes. This teaching, combined with the skilled person's understanding that larger transducers improve acoustic properties (as correctly noted by the respondent), would have readily led the skilled in the art to feature (o) to achieve these improvements.

3.4 Hence, auxiliary requests 1, 2, 4 to 6, 8, 10 and 12 to 14 are not allowable (at least) under Article 56 EPC.

4. *Auxiliary requests 3A, 3B, 4A, 7A, 9A and 11A*

4.1 The appealed decision was not based on any of **auxiliary requests 3A, 3B, 4A, 7A, 9A and 11A**. Under Article 12(4), second sentence, RPBA, the admittance of these auxiliary requests into the proceedings was at the board's discretion.

4.2 Irrespective of any admittance considerations, the board is not satisfied that the amendments in these auxiliary requests can make them allowable in terms of

inventive step. The reasons for this are as follows:

- 4.2.1 **Feature (m)** does not credibly achieve the technical effect alleged by the appellant, i.e. that it "allows to use a comparatively large driver but at the same time bringing the driver close to the entrance of the ear canal (while at the same time allowing to use a relatively large driver)". This is because the size of the "acoustic driver" referred to in feature (f) and its distance to the ear canal is not only determined by the acoustic driver's orientation with respect to the nozzle mentioned in feature (c): it further depends on the form of the earphone's housing, in particular of the structure according to feature (b) and the presence of other components such as the "feedback microphone" in accordance with feature (d).

Also the space in front of the acoustic driver's diaphragm, such as space 73 in Figure 7A of the opposed patent, is an important factor in this respect. Changing the size of this space may impact the "front cavity" (cf. paragraph [0038] of the opposed patent) and, hence, alter the operation of the claimed earphone (cf. point 2.2.2 above). Moreover, a larger acoustic driver "may cause the earphone to be mechanically unstable in the ear", as set out in paragraph [0032] of the opposed patent with respect to a prior-art configuration. The configuration according to feature (m) does not necessarily, by itself, compensate for such a mechanical instability. Nor does the board endorse the appellant's conclusion that feature (m) would "allow for providing relatively low impedances as defined in claim 1 which can improve ANR properties". Rather, feature (m) amounts, at most, to a matter of routine design.

- 4.2.2 **Feature (n)** concerns a mere matter of routine design as well. In particular, the board cannot see how the appellant's objective technical problem of "providing a favorable pressure gradient without generating an excessive time delay" could be based on a technical effect that is directly and causally linked with the radial positioning of the "feedback microphone" as per feature (n).
- 4.2.3 **Feature (p)** is anticipated by the arrangement shown in Figure 4 of D1 for the reason set out in Reasons 3.19 of the appealed decision.
- 4.2.4 **Feature (q)** is anticipated by paragraph [0056] of D1.
- 4.2.5 The fact that the acoustic driver is implemented as a module, as required by **feature (t)**, has the advantage that repairs are more easily performed than if the acoustic driver is mounted, for instance, as a part of an assembly holding the earphone's circuitry. The skilled person would have been familiar with this advantage based on their common general knowledge at the patent's filing date. They would have immediately implemented "driver assembly 33" of ANR component 22 (cf. paragraph [0053] and Figure 4 of D1) as a module to provide this advantage in the arrangement illustrated in Figure 4 of D1.
- 4.2.6 The appellant alleged, referring to the "description of the opposed patent", that **feature (u)** would have "an advantageous technical effect in comfortably stabilizing the earphone". Even if one assumes this "stabilizing" to take place *while the earphone is in use*, the board is not convinced that feature (u) can credibly bring about this technical effect over the

whole scope claimed. Regardless of whether the skilled reader would understand the meaning of the expressions "outer", "inner" and "generally follow" in this context, the "outer leg" and "inner leg" mentioned in feature (u) do not necessarily stabilise the earphone: the expression "generally follow" according to feature (u) may imply that the "outer leg" is placed inside the curve of the anti-helix wall at the rear of the concha while in use, but this does not mean that the earphone is actually stabilised as a result.

The respondent is therefore not only correct in that feature (u) is not suitable for overcoming the objection due to lack of clarity raised in Reasons 10.4 and 10.5 of the appealed decision regarding claim 1 of the then "ninth auxiliary request", but it also convincingly questioned the presence of any teaching regarding the technical function of the outer and inner leg. Even if there were any such stabilising effect, the board has doubts as to whether this effect would be "comfortably stabilizing". After all, feature (u) is silent about the material and structure of the outer leg, which the board deems to be important factors regarding the wearing comfort of an earphone (cf. also point 3.1.2 above). The board cannot immediately recognise which technical effect could be credibly attributed to feature (u). Hence, feature (u) can also not contribute to inventive step.

- 4.2.7 The appellant contended that **feature (m)**, which defines specific angles for the acoustic-driver orientation, allowed for the integration of a larger transducer, as illustrated in Figure 8E of the opposed patent. In this context, it had argued in its statement of grounds of appeal that Figure 4 of D1 suggested an angle not exceeding 30 degrees.

While acknowledging the schematic nature of Figure 4 in D1, the board finds no conclusive evidence that the depicted angle is strictly limited to 30 degrees. The skilled person might have considered a range of feasible angles, potentially exceeding 30 degrees. In fact, the board concurs with the respondent's assessment that the angle in Figure 4 of D1 appears to be closer to 45 degrees, making it a matter of routine modification for the skilled person to arrive at the values specified in feature (m).

4.3 As a result, auxiliary requests 3A, 3B, 4A, 7A, 9A and 11A are not allowable under Article 56 EPC either.

## Order

### **For these reasons it is decided that:**

The appeal is dismissed.

The Registrar:

The Chair:



B. Brückner

J. Eraso Helguera

Decision electronically authenticated