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**Datasheet for the decision
of 30 March 2016**

Case Number: T 0837/12 - 3.5.03

Application Number: 99914175.7

Publication Number: 1068773

IPC: H04R25/00, H04R3/02

Language of the proceedings: EN

Title of invention:
Apparatus and methods for combining audio compression and
feedback cancellation in a hearing aid

Patent Proprietor:
GN ReSound A/S

Opponent:
Widex A/S

Headword:
Combining audio compression and feedback cancellation in a
hearing aid/GN RESOUND

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
Main request - novelty (yes); inventive step (no)
First auxiliary request (amended) - inventive step (yes)

Decisions cited:
G 0003/14

Catchword:

Beschwerdekammern

Boards of Appeal

Chambres de recours

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Case Number: T 0837/12 - 3.5.03

D E C I S I O N
of Technical Board of Appeal 3.5.03
of 30 March 2016

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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted on 19 December 2011 revoking European patent No. 1068773 pursuant to Article 101(3)(b) EPC.**

Composition of the Board:

Chairman	F. van der Voort
Members:	T. Snell
	O. Loizou

Summary of Facts and Submissions

I.   This appeal was lodged by the proprietor (henceforth,
        appellant) against the decision of the opposition
        division revoking European patent No. EP 1068773 on the
        ground that the subject-matter of claim 1 of a main
        request and of an auxiliary request did not involve an
        inventive step (Article 100(a) EPC).

II.   The following documents are relevant to the board's
        decision:

        D1: US 5027410 A;

        D2: EP 0415677 A;

        D9: WO 94/09604 A1; and

        D12: S. Wyrsch et al, "A DSP Implementation of a
             Digital Hearing Aid with Recruitment of Loudness
             Compensation and Acoustic Echo Cancellation", 1997
             Workshop on Applications of Signal Processing to
             Audio and Acoustics, pages 1 to 4.

III.   In the statement of grounds of appeal, the appellant
        requested as a main request that the decision be set
        aside and the patent maintained as granted. The
        appellant also filed first to fourth auxiliary requests
        in the event that the main request was not allowed.

IV.   In a response to the appeal, the opponent (henceforth,
        respondent) requested that the appeal be dismissed.

        The respondent argued principally that the subject-
        matter of claim 1 of the main request was not new with
        respect to document D9, and did not involve an

inventive step with respect to either D1 (erroneously referred to as D4) combined with D9, or D12 combined with common general knowledge.

V.   Both parties conditionally requested oral proceedings.

VI.   In a further written submission, the appellant filed amended pages of all requests in which an alleged error introduced during printing was corrected (the term "convening" being changed to "converting"). The appellant also responded to the arguments raised by the respondent.

VII.   In a communication accompanying a summons to attend oral proceedings, the board gave a preliminary opinion that the subject-matter of claim 1 of each request was either not new or did not involve an inventive step.

VIII.   In a response to the board's communication, the appellant filed with a letter dated 12 February 2016 an amended main request and first and second auxiliary requests to replace the requests on file. The new main request and the first auxiliary request were said to correspond to the previous first and fourth auxiliary requests, respectively. The appellant also filed a further set of requests, referred to as "bis", in which the correction referred to above was dispensed with.

IX.   Oral proceedings took place on 30 March 2016.

        The appellant withdrew the set of requests "bis".

        The appellant requested that the decision under appeal be set aside and that the patent be maintained in amended form on the basis of the claims of the main request, or in the alternative, on the basis of the

claims of either the first or the second auxiliary
request, all requests as filed with the letter of
12 February 2016.

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

X.   Claim 1 of the main request reads as follows:

"A hearing aid comprising:
a microphone (202) for converting sound into an audio
signal;
feedback cancellation means (250, 350) including means
for estimating a physical feedback signal of the
hearing aid, and means for modelling a signal
processing feedback signal to compensate for the
estimated physical feedback signal;
subtraction means (208), connected to the output of the
microphone and the output of the feedback cancellation
means, for subtracting the signal processing feedback
signal from the audio signal to form a compensated
audio signal;
hearing aid processing means (240, 340), connected to
the output of the subtractor, for processing the
compensated audio signal; and
speaker means (220), connected to the output of the
hearing aid processing means, for converting the
processed compensated audio signal into a sound signal;
wherein said feedback cancellation means forms a
feedback path from the output of the hearing aid
processing means to the input of the subtracting means;
and wherein said hearing aid processing means includes
compression means (40) for performing audio
compression; said hearing aid further comprising:
means (406) for providing information from the feedback
cancellation means to the compression means, and

wherein said compression means adjust its *[sic]*
operation based upon information provided by the
feedback cancellation means."

XI.   Claim 1 of the first auxiliary request is the same as
        claim 1 of the main request except that the following
        wording is added to the the end of the claim:

        ", and wherein the feedback cancellation means includes
        a zero filter (212); the hearing aid includes means for
        calculating a norm of a vector of coefficients of the
        feedback cancellation means zero filter, and the
        compression means modifies a gain value based on the
        norm."

        The remaining claims, i.e. claims 2 to 9, are dependent
        on claim 1.

XII.   In view of the board's decision, it is not necessary to
        recite claim 1 of the second auxiliary request.

Reasons for the Decision

1.   General

        The present patent concerns a hearing aid comprising
        audio processing means, including audio compression
        means, in a forward path between a microphone and a
        speaker, and feedback cancellation means in a reverse
        path, which aim to estimate and cancel the physical
        audio feedback signal by subtracting an estimated
        signal from the signal output by the microphone. Very
        broadly stated, the patent discloses a concept
        concerned with, inter alia, providing information from
        the feedback cancellation means to the compression

means in order to prevent loop instability, and thus
prevent whistling or howling of the hearing aid.

2.   *Main request – claim 1 – novelty with respect to D9*

2.1   It was not disputed that D9 discloses all the features
        of claim 1 except for the features:

        "said hearing aid processing means includes compression
        means (40) for performing audio compression; said
        hearing aid further comprising:
        means (406) for providing information from the feedback
        cancellation means to the compression means, and
        wherein said compression means adjust its *[sic]*
        operation based upon information provided by the
        feedback cancellation means".

2.2   The respondent argued that these features were also
        disclosed in D9. In this respect, the respondent argued
        that the multiplication circuit 211 combined with the
        limiter circuit 15 in Fig. 2 performed the same
        function as a compression circuit, which was to make
        soft sounds louder without making loud sounds louder.

2.3   However, in the board's view, neither the
        multiplication circuit 211 nor the limiter 15, nor the
        combination, performs the function of a compression
        circuit.

2.4   As regards the multiplication circuit 211, this is
        controlled to reduce the gain when the loop gain
        exceeds a predetermined value K (cf. page 10, lines 19
        to 26). This control of the multiplication value is not
        based on the level of the input signal, i.e. is not
        controlled in order to "make soft sounds louder without

making loud sounds louder", and therefore not related
to audio compression.

2.5   As regards the limiter circuit 15, the board notes that
        limiter circuits are of two broad types:

        (a) circuits which merely clip the signal to a desired
        maximum level; and

        (b) circuits where the gain is controlled in order to
        prevent the signal exceeding a desired level.

        A type (b) limiter functions in a manner similar to a
        compression circuit, as explained by the respondent in
        the letter dated 23 December 2013, cf. page 3, last
        paragraph ("Typically there will be a level detector
        and a mechanism for adjusting the gain depending on the
        level detected."). Therefore, a type (b) limiter
        arguably is a compression circuit. However, a type (a)
        limiter has no gain control mechanism and is clearly
        not a compression circuit.

2.6   As regards D9, the limiter is apparently of type (a),
        i.e. not a compression circuit. This follows from the
        reference in D9 to the limiter disclosed in document D2
        (cf. D9, page 5), which is clearly of type (a), i.e.
        not a compression circuit (cf. D2, Fig. 5 and col. 6,
        lines 38-48); see also the statement of grounds of
        appeal, middle of page 3).

2.7   As neither the gain circuit nor the limiter provides a
        compression function, neither does the combination of
        these elements.

2.8   As D9 does not disclose a compression circuit, the
        subject-matter of claim 1 is new with respect to the
        disclosure of D9 (Articles 52(1) and 54 EPC).

*3.   Main request – claim 1 – inventive step with respect to
        the combination of D1 and D9*

3.1   It was not in dispute that D1, in particular Fig. 15
        and the associated text, discloses all the features of
        claim 1 with the exception of the features:

        "means for providing information from the feedback
        cancellation means to the compression means, and
        wherein said compression means adjust its *[sic]*
        operation based upon information provided by the
        feedback cancellation means".

3.2   The problem to be solved by these features is to
        prevent the loop consisting of the [forward] processing
        means and the feedback cancellation means becoming
        unstable.

3.3   D9 provides a solution to this problem (cf. page 11,
        lines 10 to 17) consisting of determining the loop gain
        and reducing the forward gain if the loop gain reaches
        a threshold value (cf. page 11, lines 17 to 26). The
        loop gain is obtained from the filter coefficients of
        feedback cancellation means FIR 27 (cf. page 11, lines
        26 to 32 and page 12, lines 7 to 28). In the board's
        view, the skilled person would attempt to apply this
        same solution to the system of D1, Fig. 15 to counter
        the problem of loop instability. An obvious way to
        implement this solution that would occur to the skilled
        person is to control the gain of the "hearing aid
        signal processing" block (i.e. the compression circuit)
        in Fig. 15 of D1 based on the filter coefficients from

the "Filter estimator". The skilled person would thus arrive at the subject-matter of claim 1 without inventive skill.

3.4   The appellant presented the following counter-arguments at the oral proceedings:

(i) The skilled person would not look to D9 as it provides for feedback cancellation using a noise generator which injects wide band noise in order to correctly adapt the FIR filter 27. The only way to apply the teaching of D9 would be to include the noise generator, since without it, it would be impossible to calculate a good estimate of the open loop gain due to the limited spectrum of the feedback signal. However, the skilled person would reject any solution using a noise generator, since such hearing aids were known to be uncomfortable for the wearer. This would thus be a retrograde step that the skilled person would not envisage.

(ii) D1 discloses a system with stability problems since the forward gain path is non-linear. The skilled person would not look to D9 for a solution as it describes a system with linear gain in the forward path.

3.5   Re (i): The board is unconvinced that the skilled person would reject D9 on the basis that it includes a noise generator, and moreover does not agree that any solution based on D9 must include a noise generator. In this respect, the above-mentioned section of D9 (i.e. page 11, lines 17 to 26) describing a solution to the aforementioned technical problem is essentially self-contained and makes no reference to the noise generator. Furthermore, in accordance with D9, it is

only necessary to carry out an <u>approximate</u> calculation
of the actual loop amplification (cf. page 11, lines 17
to 21), i.e. accuracy is not essential. Self-evidently,
a lack of accuracy could easily be taken into account
by choosing a conservative value of K, the constant
which regulates when to reduce the hearing aid's
amplification (cf. page 10, lines 19 to 23, and page
12, lines 7 to 28).

Re (ii): The board sees no inherent issue with non-
linearity that would dissuade the skilled person from
applying the approach of D9. A greater tendency to
instability can again be taken into account when
choosing the value K.

3.6   In the written proceedings, the appellant argued that
        if D9 were combined with D1, a gain element would be
        placed at the output of the compression circuit.
        Consequently, there would be no control of the
        compression circuit itself.

        However, the board notes that the compression circuit
        has gain calculation elements in each frequency band
        (cf. Fig. 8). Consequently, it would occur to the
        skilled person that it would be more efficient to
        reduce the gain of these elements rather than to
        introduce an extra gain circuit. However, even in the
        case that a further gain element were placed after the
        compression circuit, this gain element could still be
        regarded as part of the "compression means" defined in
        claim 1.

        The board therefore finds the appellant's arguments
        unconvincing.

3.7   The board concludes that the subject-matter of claim 1 does not involve an inventive step (Articles 52(1) and 56 EPC).

4.   *First auxiliary request – claim 1 – amendments (Articles 123(2) and 123(3) EPC)*

4.1   Claim 1 of the first auxiliary request differs from claim 1 of the main request in that it additionally includes the features:

        "wherein the feedback cancellation means includes a zero filter (212); the hearing aid includes means for calculating a norm of a vector of coefficients of the feedback cancellation means zero filter, and the compression means modifies a gain value based on the norm".

4.2   These added features result in a further limitation of claim 1 as granted, and hence the claim complies with Article 123(3) EPC.

4.3   This added wording is based verbatim on claim 7 as originally filed. Consequently, compliance with Article 123(2) EPC is not in doubt and was not contested.

5.   *First auxiliary request – claim 1 – interpretation*

5.1   The wording added to claim 1 was already included in claim 6 as granted. Consequently, the board is not empowered to examine this amendment for compliance with Article 84 EPC (cf. G 3/14). Nevertheless, certain terms require interpretation before the claim can be examined for inventive step:

A "zero filter" is understood as a filter comprising only zeroes, i.e. no poles, also known as an "all-zero filter".

A "norm of a vector of coefficients", in accordance with the normal meaning of the term "norm of a vector", is regarded as a value representing the length of the vector of coefficients calculated from the square root of the sum of the squares of the coefficient magnitudes. The respondent argued that the term "norm" was vague, and embraced the magnitude of a single coefficient of the vector. This had also been the view of the opposition division (cf. the impugned decision, page 10, third paragraph). The board however notes that "coefficients" in the term "norm of a vector of coefficients" is a plural entity. Consequently, there are at least two coefficients involved in the calculation of the norm.

6.   *First auxiliary request – claim 1 – inventive step*

6.1   It was not disputed that D9 discloses a "zero filter", since the FIR filter 27 in Fig. 2 is implicitly an all-zero filter. It was also not in doubt that the adjustment of the multiplication circuit 211 was based on the coefficients of the FIR filter "FIRCOEF" (cf. page 12, lines 7 to 28).

6.2   D9 is not explicit as to how the filter coefficients are used in the calculation of loop gain to control the multiplication circuit 211. However, D9 clearly teaches that the loop gain is calculated at different frequencies (cf. page 3, lines 20 to 26; page 10, line 35 to page 11, line 3; page 11, lines 17 to 22; page 12, lines 7 to 28).

6.3   The appellant argued at the oral proceedings (see also
       the statement of grounds of appeal on page 9) that in
       order to calculate the gain at a given frequency ω, the
       following expression representing the transfer function
       of the zero filter has to be evaluated (f_0 ... f_{N-1}
       being the filter coefficients):

       $$H(j\omega) = f_0 + f_1 e^{-j\omega} + f_2 e^{-j2\omega} \ldots + f_{N-1} e^{-j(N-1)\omega}$$

       This required a number of calculations at each
       frequency, which was time consuming and costed power.
       The coefficient vector norm here would be of no use as
       it had no frequency component. On the other hand,
       calculating the norm as claimed was much simpler and
       led to a more rapid response.

6.4   The respondent argued that in accordance with D9 the
       skilled person would have to calculate a scalar value
       from the vector of coefficients. The most natural
       choice would be the norm of that vector, in particular
       because this vague term embraced even taking a single
       coefficient as the norm.

6.5   Considering that D9 requires an open loop gain value to
       be calculated at specific frequencies, the board is
       persuaded by the argument of the appellant that D9
       teaches away from using a norm of the vector
       coefficients to control gain, since the norm value
       calculated from at least two filter coefficients would
       not be a scalar value related to the gain at a specific
       frequency. The board can thus see no motivation in D9
       to calculate the norm of the vector of filter
       coefficients. This step is therefore not obvious.

6.6   The board concludes that the subject-matter of claim 1
        involves an inventive step with respect to the
        combination of D1 and D9 (Articles 52(1) and 56 EPC).

7.   *First auxiliary request – claim 1 – inventive step
        starting out from D12*

7.1   D12 describes a hearing aid with the same basic
        structure as the hearing aid according to the present
        patent, in that Fig. 1 shows both compression means
        ("Feedforward Filter") in a forward path and feedback
        cancellation means ("Predictor") in a reverse path.

7.2   D12 describes a method for preventing instability based
        on determining an estimate of the open loop gain $K_0[k]$,
        which is calculated based on the error signal E(k)
        derived from a DFT of the output of the subtractor
        which subtracts the cancellation signal from the input
        signal. The formula for $K_0[k]$ is based on formula (13)
        on page 4. This formula includes no terms based on the
        coefficients of the predictor.

7.3   However, formula (13) is said to be motivated by
        formula (11) on page 2 (cf. page 3, right-hand col.,
        last paragraph). This formula includes a term
        $\left|\tilde{H}_i[k]\right|^2$. It follows from col. 2, line 17 that
        $\tilde{H}[k] = H - \hat{H}[k]$, H being the acoustic feedback path
        and $\hat{H}[k]$ being the predictor transfer function.

7.4   The respondent argued that this showed that K_0 could be
        calculated from equation (11) instead of equation (13).
        Further, in equation (11), $\tilde{H}$ could be replaced by $H-\hat{H}$.
        The terms of the equation can then be re-formulated
        such that the modulus of $H-\hat{H}$ has to be calculated. By
        expanding this expression, one arrives at an expression

including the term $\sum\hat{H}^2$, which the respondent considered
to be the norm of $\hat{H}$.

In reply, the appellant argued that equation (11) could
not be used in practice because the acoustic feedback
path H was unknown.

To this, the respondent argued that although H was not
generally known, it could be determined under
laboratory conditions such as described in section V of
D12, in particular in order to check the reliability of
determining K_0 using equation (13).

7.5   The board however finds the respondent's arguments
        unconvincing. Firstly, it is pure speculation whether
        the skilled person would attempt to check the
        reliability of equation (13) by computing equation (11)
        under laboratory conditions given a known audio
        feedback transfer function. Indeed, it is not known
        whether it would be even possible to know this transfer
        function accurately. Secondly, it is uncertain whether
        the test arrangement described in section V can fairly
        be considered to be a "hearing aid" within the meaning
        of claim 1, since the system appears to contain
        processing elements on a DSP board external to a
        "dummy" hearing aid worn by a "KEMAR-head". Finally,
        the respondent's mathematical analysis is unconvincing,
        since even if the skilled person performed the
        mathematical steps alleged by the respondent, it
        appears that, rather by chance than design, at most a
        quantity including, inter alia, squared terms of the
        norm of $\hat{H}$ might be involved. The board can see no
        obvious reason why the skilled person would then take
        the square root of these terms only in order to obtain
        the norm of $\hat{H}$, and neither did the respondent provide
        one. In the board's view, the respondent's attack

clearly relies on a highly speculative ex-post facto analysis.

7.6   The board concludes that the subject-matter of claim 1 involves an inventive step when starting out from D12 (Articles 52(1) and 56 EPC).

8.   *First auxiliary request – inventive step – the combination of D1, D9 and D12*

The respondent also argued that the skilled person would arrive at the subject-matter of claim 1 by combining the documents D1, D9 and D12. However, since D12 does not disclose the inventive feature of basing the hearing aid gain on a norm of the vector of coefficients, even combining D12 with D1 and D9 would not lead to the subject-matter of claim 1. Consequently, this attack also fails.

9.   *Dependent claims*

No objections were raised concerning the dependent claims, i.e. claims 2 to 9.

10.   *Grounds for opposition under Article 100(b) and Article 100(c) EPC*

The opposition division found that the grounds for opposition pursuant to Article 100(b) and (c) EPC (cf. Articles 83 and 123(2) EPC) did not prejudice the maintenance of the patent as granted. The respondent has not contested this part of the decision and did not raise any objections based on these grounds in respect of the present first auxiliary request. Nor does the board see any reason to raise any such objections.

11.   Conclusion

The claims according to the first auxiliary request meet the requirements of the EPC. The patent can therefore be maintained in amended form on the basis of this request (Article 101(3)(a) EPC). However, the board has not examined the description or drawings for compliance with the EPC, and considers that this matter is best dealt with by the opposition division.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to maintain the patent in amended form on the basis of claims 1 to 9 of the first auxiliary request as filed with letter of 12 February 2016, and a description and drawings to be adapted accordingly.

The Registrar: The Chairman:

G. Rauh   F. van der Voort

Decision electronically authenticated