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D E C I S I O N
of 1 October 2002

Case Number: T 1150/00 - 3.5.1

Application Number: 89107051.8

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Language of the proceedings: EN

Title of invention:
Electroacoustic driving circuit

Patentee:
YAMAHA CORPORATION

Opponent:
AIWA CO., LTD.

Headword:
Driving circuit/YAMAHA

Relevant legal provisions:
EPC Art. 54, 56, 108, 123(2)
EPC R. 65(1)

Keyword:
"Admissibility of appeal (yes)"
"Novelty (main request: no)"
"Added subject-matter (first auxiliary request: yes)"
"Inventive step (second and third auxiliary requests: no)"

Decisions cited:
T 0744/99

Catchword:
-



Case Number: T 1150/00 - 3.5.1

D E C I S I O N
of the Technical Board of Appeal 3.5.1
of 1 October 2002

Appellant: YAMAHA CORPORATION
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 11 August 2000
revoking European patent No. 0 339 470 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: S. V. Steinbrener
Members: A. S. Clelland
E. Lachacinski

Summary of Facts and Submissions

- I. This appeal is against the decision of the opposition division to revoke European patent No. 339 470 on the grounds that claim 1 of the main request infringed Article 123(2) EPC (added subject-matter) whilst the subject-matter of claim 1 of first and second auxiliary requests respectively lacked novelty and inventive step. A third auxiliary request was not admitted on the ground that it was late-filed, Rule 71(a) EPC.
- II. In the course of the opposition proceedings two documents were discussed, of which one has been relevant to the present appeal:
- D1: A. N. Thiele: "Loudspeakers in Vented Boxes"
Journal of the Audio Engineering Society; Part I:
Vol. 19, No. 5, May 1971, pages 382 to 392;
Part II: Vol. 19, No. 6, June 1971, pages 471 to 483.
- III. In the notice of appeal and subsequent statement of grounds of appeal the appellant (patentee) requested that the decision of the opposition division be set aside and as a main request, that the patent be maintained as granted. Sets of claims of first to third auxiliary requests were also filed. The appellant furthermore requested oral proceedings. In the statement of grounds of appeal it was argued that claim 1 of the second auxiliary request was clear and furthermore both novel and inventive.
- IV. The respondent (opponent) in reply requested that the appeal be dismissed and made a conditional request for oral proceedings. It was argued that the appeal was inadmissible because it dealt only with the second auxiliary request and gave no reasons why the decision

under appeal should be set aside. However, were the Board to find the appeal admissible, none of the requests were allowable: claim 1 of the main request lacked novelty, whilst claim 1 of the first auxiliary request contained added subject-matter. Claim 1 of the second auxiliary request lacked an inventive step and was arguably not novel, whilst claim 1 of the third auxiliary request contained added subject-matter and moreover lacked an inventive step.

V. The Board summoned the parties to oral proceedings, to take place on 1 October 2002. Shortly before the oral proceedings the respondent withdrew the request for oral proceedings and announced that he would not be attending. The oral proceedings nevertheless took place as announced in the absence of the respondent. At these proceedings the appellant maintained the requests filed with the statement of grounds of appeal.

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

"A system comprising a driving apparatus and a vibrator (4), the driving apparatus comprising a drive circuit for providing a drive signal to the vibrator (4), the drive circuit having an output impedance (Z_0) which varies with frequency, the vibrator (4) being arranged in a resonator (1, 8) constituted by a closed cavity (1) and an acoustic mass means (8) for causing said cavity (1) to acoustically communicate with an external region so as to directly radiate an acoustic wave to the outside, the vibrator (4) being driven by the driving apparatus to cause the resonator (1, 8) to radiate a resonant acoustic wave through said acoustic mass means (8) to the outside, **characterized in that** the output impedance (Z_0) of the drive circuit is negative in the low frequency range and is positive in the high frequency range wherein the low frequency range includes a first resonance frequency which is

determined by the motional frequency of said vibrator (4) and the equivalent stiffness of said cavity (1) and a second resonance frequency which is the resonance frequency of said resonator (1, 8)."

- VII. Claim 1 of the first auxiliary request amends the reference in the characterising part to "motional frequency" to refer to "motional impedance" and adds to the above claim the following feature:

"and that the values of the output impedance (Z_0) at the first and second resonance frequencies are set independently of and differently from each other thereby enabling Q values at said resonance frequencies to be set to be desirable values respectively".

- VIII. Claim 1 of the second auxiliary request has the same preamble as claim 1 of the main request and the following characterising part:

"the output impedance (Z_0) of the drive circuit is made negative in the low frequency range by positive current feedback and is made positive in the high frequency range by negative current feedback wherein the low frequency range includes a first resonance frequency which is determined by the motional impedance of said vibrator (4) and the equivalent stiffness of said cavity (1) and a second resonance frequency which is the resonance frequency of said resonator (1, 8)."

- IX. Claim 1 of the third auxiliary request is based on claim 1 of the second auxiliary request and specifies that the resonator is a Helmholtz resonator and the

first resonance frequency is higher than the second resonance frequency; the claim also includes the following additional feature:

"the drive circuit including a feedback circuit (33) constituted by an amplifier (33b) having positive (non-inverting) and negative (inverting) input terminals, a low pass filter (33a) for allowing only a low-frequency component of an AC voltage signal to pass therethrough to supply it to the positive input terminal of the amplifier (33b), and a high-pass filter (33c) for allowing only a high-frequency component of the AC voltage signal to pass therethrough to supply it to the negative input terminal of the amplifier (33b)".

- X. At the end of the oral proceedings the chairman declared the debate closed and announced the Board's decision.

Reasons for the Decision

- 1. Admissibility of the appeal.
 - 1.1 The respondent raised the issue of whether the appeal is admissible; he drew attention to the statement of grounds of appeal and argued that the only request properly supported was the second auxiliary request.
 - 1.2 In the Board's view, it suffices for an appeal to be admissible under Rule 65(1) EPC if the statement of grounds gives adequate reasons with respect to one of the requests considered not allowable in the impugned decision.

1.3 In the present case, the Board notes that the statement of grounds of appeal makes clear requests, followed by a statement at page 2 that "The following discussion ... is directed primarily to the Second Auxiliary Request". The arguments which follow this statement are said to be in support of the clarity of the claims and do not appear to apply exclusively to the second auxiliary request; they are apparently primarily concerned with the interpretation of the terms used in the patent. This discussion is followed by a detailed consideration of the prior art.

1.4 Hence, the arguments in the statement of grounds are even sufficiently general to be of relevance to all requests. In these circumstances the Board considers that the statement of grounds is sufficiently reasoned with respect to all requests in accordance with the principles set out in the established jurisprudence of the boards of appeal. The appeal is accordingly admissible.

2. *Technical background*

2.1 Bass reflex speaker systems (see Figures 41A and 41B of the patent in suit) are well known in the acoustic engineering art and comprise, in the simplest form, a resonant cavity on one wall of which a loudspeaker (which the patent refers to as a "vibrator") is mounted and with a vent or port connecting the cavity to the outside world and which is also resonant. Such a system can be represented electrically by two resonant circuits connected in parallel (see Figure 42 of the patent): a parallel resonant circuit, the inductive and capacitive components of which correspond to the speaker motional impedance, and a series resonant circuit of which the inductive component corresponds to the stiffness of the resonant cavity or cabinet and the capacitive component to the mass within the port. In

series with these resonant circuits is a resistance representing the loudspeaker voice coil resistance. The resonant circuits give rise to variations in sound pressure with frequency and to specific resonances of which two are relevant to the present discussion (see Figure 43 of the patent), namely the resonance arising from the cabinet stiffness and port mass, referred to in the patent as " f_2 " and the resonance arising from the interaction of the speaker with the cabinet, referred to in the patent as " f_1 ". The sharpness, or "Q", of the resonance depends to some extent on cabinet volume, so that a small cabinet will have a high Q for f_1 and a low Q for f_2 , resulting in an impaired frequency response. One answer to this problem, which the appellant acknowledged in the course of the oral proceedings was known *per se* in the acoustic engineering art, is to drive the speaker with a negative impedance. By this means the voice coil resistance of the speaker can be substantially cancelled, with the result that the Q at frequency f_1 can be decreased and that at frequency f_2 increased. However, a problem which arises is that the Q of both circuits is changed simultaneously and it would be advantageous if each could be adjusted independently. One object of the invention is to enable this to be done, see column 8, lines 8 to 18 of the patent. Another aspect is that the use of a negative driving impedance gives rise to problems in the higher frequency range as the use of negative driving impedance can give rise to non-linear components, see column 7, lines 39 to 46 and column 8, lines 30 to 38 of the patent.

- 2.2 Both these problems are solved by varying the driving impedance over the frequency range. Thus, in order to enable the Q of the resonances represented by f_1 and f_2 to be set independently, the negative driving impedance differs between these frequencies. This is discussed in connection with a first embodiment shown at Figures 5

to 26 of the patent. In order to reduce distortion the driving impedance above these resonances is set to be either zero or positive in value, see the third embodiment shown at Figures 30 to 39. It is noted that the second embodiment (Figure 27 and 28) is not the subject of any of the claims.

3. *Added subject-matter*

3.1 Before turning to novelty and inventive step the Board considers it appropriate to address the question of whether claim 1 of the first and third auxiliary requests is based on subject-matter disclosed in the originally filed application.

3.2 Claim 1 of the main request is directed to the second of the two problems discussed at paragraph 2.1 above, corresponding to the third embodiment. Thus, claim 1 of the main request requires a drive circuit output impedance which is "negative in the low frequency range and is positive in the high frequency range", "the low frequency range" being said to include the two resonance frequencies referred to above. In other words, in accordance with claim 1 the driving impedance changes from being negative at lower frequencies to positive at higher frequencies. Claim 1 of the first auxiliary request adds the feature that the values of the driving impedance at the first and second resonance frequencies are "set independently of and differently from each other"; this feature is as discussed above disclosed in connection with the first embodiment.

3.3 The Board has been unable to identify any disclosure in the originally filed application in which these two aspects, ie varying the negative impedance between the two resonance frequencies and making it positive in a higher frequency range, are combined in a single embodiment. In the course of the oral proceedings the

appellant argued that the third embodiment should be read together with the first embodiment rather than as an alternative use of a variable negative driving impedance. It was argued that columns 11 and 12 of the granted patent, corresponding to columns 12 and 13 of the application as filed, combined the teaching of the two embodiments as could be seen by a comparison of the figures, Figures 3, 6 and 22 of the first embodiment corresponding respectively to Figures 29, 31a/b and 33 of the third embodiment. The Board does not agree; whilst these figures show that the principle of varying source impedance with frequency is used in both embodiments, it is used for different purposes, as discussed above. The application as filed nowhere discloses or even suggests an embodiment in which both aspects are combined. The similarity in the drawings pointed out by the appellant arises from the fact that in each embodiment the driving impedance changes at a preset frequency, this change being between the frequencies f_1 and f_2 in the first embodiment and above both f_1 and f_2 in the third embodiment. For both changes to take place in the one embodiment it would be necessary to provide further circuitry.

- 3.4 The appellant argued that the skilled person, reading the originally filed application as a whole, would appreciate that the two aspects of the invention could be combined. The Board observes that the implication behind this comment is that it would be obvious to combine the two embodiments; the appropriate test in the present case is however whether the skilled person could derive the claimed subject-matter directly and unambiguously, using common general knowledge, from the originally filed application as a whole. Reference is directed to this Board's decision T 744/99 (not published in OJ EPO), which states that the application

of common general knowledge can only serve to interpret the meaning of a technical disclosure and place it in context; it cannot be used to complete an otherwise incomplete technical disclosure.

3.5 The Board accordingly concludes that the claimed combination is not directly and unambiguously derivable from the originally filed application and therefore adds subject-matter, Article 123(2) EPC. The first auxiliary request is accordingly not allowable.

3.6 The respondent also argued that claim 1 of the third auxiliary request did not comply with Article 123(2) EPC because a Helmholtz resonator was claimed but the third embodiment only disclosed a simple loudspeaker. The Board notes however that the introduction to the description at column 13, lines 28 to 33 of the published application refers to bass reflex speakers in the context of the third embodiment, so that this request does not give rise to objection under Article 123(2) EPC.

4. *Novelty (main request)*

4.1 It was acknowledged by the appellant in the course of the oral proceedings that the subject-matter of the preamble of claim 1 was known from D1, as was the use of a drive circuit having an output impedance which varies with frequency. The discussion at the oral proceedings was accordingly on the question of whether D1 disclosed the use of a negative driving impedance in a low frequency range including the first and second resonance frequencies and a positive driving impedance in a high frequency range. The Board notes that D1 refers at page 386 to the total Q of the loudspeaker, Q_t , being "controlled by the source impedance of the amplifier" (right-hand column, final paragraph of section IV). The cited passage also states that "if the

required Q_t is greater than the speaker's natural Q , a positive output impedance will be required of the amplifier ... If less, a negative output impedance will be required ...". The passage goes on to state that there is a practical limit if the degree of negative impedance required is too large and that this is discussed in section XII of the text. This section starts at page 475, left-hand column, and is preceded by a table showing how amplifier output impedance changes with type of feedback; thus, negative voltage feedback and positive current feedback decrease the amplifier output impedance whereas positive voltage feedback and negative current feedback increase it. It is stated at the foot of the left-hand column, page 475 that "we will want to eliminate the negative impedance characteristic at the higher audio frequencies for reasons that will be discussed later". These reasons are given at page 476, left-hand column, first full paragraph, where it is stated that at high frequencies a negative impedance reduces high frequency response and that "This is usually undesirable, so the negative impedance should be eliminated at the higher audio frequencies". The preferred method of doing so is shown at Figure 14b at page 476 in which a feedback circuit is shown between the output winding of an amplifier output transformer and the speaker itself. This circuit gives two types of feedback: voltage feedback from the potential divider represented by on the one hand R_3 and on the other hand R_5 and R_6 across the transformer output and current feedback derived from R_2 . It is stated in the passage bridging the columns on page 476 that by the use of a capacitor C "the output impedance will change from a negative value at low frequencies to a small value, either positive or negative depending on the particular circuit. The frequency of changeover ... should be ... two octaves above f_h ". f_h can be seen from

Figure 5 on page 385 and the associated text at page 476, right-hand column, last paragraph to be the higher frequency of the two loudspeaker impedance peaks in the low frequency region, ie corresponding to f_1 in the patent.

4.2 The skilled person is accordingly taught by D1 to provide a negative driving impedance in the lower frequency region and at the higher frequency region to provide a driving impedance which has "a small value, either positive or negative depending on the particular circuit" (sentence bridging left and right-hand columns on page 476). D1 accordingly envisages the case which is the subject of the claim, namely a negative driving impedance in the low frequency range and a positive - albeit slightly positive - driving impedance in the higher frequency range. It is however observed that on the one hand the claim does not specify any particular range of positive impedance values and that on the other hand the discussion in D1 is in the context of the Figure 14b circuit; the tenor of the document as a whole is that any degree of feedback, either positive or negative, can be provided as required by the loudspeaker system in use. Thus, page 475, left-hand column indicates that in order to provide a required Q, "a suitable adjustment can easily be made, for example, by changing the positive current feedback to negative current feedback".

4.3 The subject-matter of claim 1 of the main request accordingly lacks novelty, Article 52(1) and 54 EPC.

5. *Inventive step (second auxiliary request)*

5.1 Claim 1 of the second auxiliary request in essence adds to claim 1 of the main request that the driving impedance is made negative in the low frequency range by positive current feedback and positive in the high

frequency range by negative current feedback. This is intended to distinguish from the disclosure of D1, which in the Figure 14b embodiment appears to use a combination of positive current feedback and negative voltage feedback. However, the document tells the skilled person what alternatives are available in order to achieve any desired output impedance, see the table at the top of page 475, left-hand column, discussed above. Even though the only described embodiment combines voltage and current feedback the skilled person is made aware that he can use whatever feedback provides the required impedance. As quoted above, page 475 left-hand column, first paragraph states that Q can be adjusted "by changing the positive current feedback to negative current feedback", no indication as how this is to be done being given, implying that it is well within the competence of the ordinarily skilled person.

5.2 The Board accordingly concludes that the skilled person, starting out from the teaching of D1 and seeking to provide both a negative driving impedance in a low frequency range and a positive driving impedance in a high frequency range, would find it obvious to use only current feedback. The subject-matter of claim 1 of the second auxiliary request accordingly does not involve an inventive step (Article 56 EPC).

6. *Inventive step (third auxiliary request)*

6.1 Claim 1 of this request adds to claim 1 of the main request that the resonator is a Helmholtz resonator and that the first resonance frequency is higher than the second resonance frequency; since any base reflex cabinet can be described as a Helmholtz resonator and the order in which resonances occur is a physical

characteristic of any base reflex system, these features do not serve to distinguish the claim with respect to the bass reflex systems described in D1.

6.2 The claim also adds to claim 1 of the main request details of the manner in which the current feedback is generated, based on Figure 33 of the patent and the associated text at column 22, lines 15 to 30. It was argued by the appellant that the prior art contained no teaching of how any feedback system should be implemented. The very specific details now claimed could not be derived from any prior document. Claim 1 was accordingly both novel and inventive.

6.3 The respondent argued in writing that the claimed arrangement followed from D1 in an obvious way. Since a person of ordinary skill learned from D1 that the negative impedance characteristic should be eliminated at the higher audio frequencies and negative current feedback increased output impedance while positive current feedback decreased it, it followed that positive current feedback should be used in the low frequency region, to attain a negative driving impedance, and negative current feedback in the high frequency region to make the driving impedance positive. It was within the general knowledge of a person of ordinary skill to use a low-pass filter for getting a low frequency component and a high-pass filter for getting a high-frequency component and thus to obtain the necessary low and high frequency components of the feedback signal (page 11 of the respondent's letter dated 30 July 2001). It was also within this person's general knowledge to obtain the positive version of the low frequency component and the negative version of the high frequency component by an amplifier having non inverting and inverting input terminals, namely a differential amplifier.

- 6.4 The Board finds the respondent's argument to be the more convincing. The circuit used in Figure 33 of the patent is made up of components which are well-known in the electronics art and which the skilled person, desiring to implement negative and positive current feedback at different frequencies, would be aware of. Given that no inventive step is involved in providing the specified feedback characteristics, no inventive skill would appear to be involved in making use of the claimed circuitry to provide these characteristics.
- 6.5 The Board accordingly concludes that the subject-matter of claim 1 of the third auxiliary request lacks an inventive step.
7. There being no allowable request, it follows that the appeal must be dismissed.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

M. Kiehl

S. V. Steinbrener