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D E C I S I O N
of 24 January 2001

Case Number: T 0709/99 - 3.5.1

Application Number: 88121164.3

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Language of the proceedings: EN

Title of invention:
Acoustic apparatus

Patentee:
YAMAHA CORPORATION

Opponent:
AIWA CO., LTD.

Headword:
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Relevant legal provisions:
EPC Art. 52(1), 54

Keyword:
"Novelty (no)"

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-

Catchword:
-



Case Number: T 0709/99 - 3.5.1

D E C I S I O N
of the Technical Board of Appeal 3.5.1
of 24 January 2001

Appellant:
(Opponent)

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Decision under appeal:

Interlocutory decision of the Opposition Division
of the European Patent Office posted 25 May 1999
concerning maintenance of the European patent
No. 0 322 686 in amended form.

Composition of the Board:

Chairman: P. K. J. van den Berg
Members: A. S. Clelland
H. Preglau

Summary of Facts and Submissions

- I. This appeal is against the decision of the Opposition Division to maintain European patent No. 322 686 in amended form.
- II. The opposition proceedings were primarily concerned with the novelty and clarity of claim 1, the sole independent claim. The opponent had *inter alia* cited the following document:
- O1: 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 (A.N. Thiele)
- III. The Opposition Division held that claim 1 as granted was unclear but that an amended claim was both clear and novel. It additionally indicated, although the objection had not been raised by the opponent, that the subject-matter of amended claim 1 involved an inventive step. Consequently the patent was maintained in amended form.
- IV. The appellant (opponent) lodged an appeal against this decision and paid the prescribed fee; it was requested that the decision under appeal be set aside and the patent revoked. A statement of grounds of appeal was subsequently filed, arguing that the amended claim 1 was either unclear or gave rise to objection under Article 123 EPC and, insofar as it could be understood, lacked novelty on the basis of the documents considered by the Opposition Division. The respondent (patentee) agreed with the findings of the Opposition Division and requested that the appeal be rejected and the patent maintained as amended. Both parties made auxiliary requests for oral proceedings.

In a communication the rapporteur, on behalf of the Board, *inter alia* queried the clarity of certain terms used in claim 1, in particular "low" resonance frequency and "super bass" reproduction. In response, the respondent filed three additional requests: a first auxiliary request was for maintenance on the basis of the granted claims, whilst second and third auxiliary requests were for maintenance on the basis of respective independent claims filed with the response.

V. Oral proceedings were held on 24 January 2001. At the commencement of the oral proceedings the respondent withdrew the first auxiliary request. Otherwise the parties maintained their requests unchanged.

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

"1. An acoustic apparatus comprising:

- a resonator (10) having a resonance radiation unit (11) for radiating an acoustic wave by resonance and being equivalent to a series resonance circuit, wherein said resonator (10) comprises a cabinet (14) having a first opening in which a vibrator (20) is disposed and a second opening serving as said resonance radiation unit (11), and wherein said resonator (10) comprises a Helmholtz's resonator having an opening port as said second opening;

- a vibrator (20) having a diaphragm (21) including a direct radiation portion for directly radiating an acoustic wave and a resonator driver portion for driving said resonator (10) and being equivalent to an internal impedance Z_v and a parallel resonance circuit Z_1 , wherein said diaphragm (21) of said vibrator (20)

constitutes said direct radiator portion on a portion facing an outer region of said cabinet (14), and constitutes said resonator driver portion on a portion facing an inner surface of said cabinet (14); and

- a vibrator drive means (30),

characterized in that

- said vibrator drive means (30) has a drive control means (31) for controlling a drive condition of said vibrator (20) and reducing the internal impedance inherent to said vibrator (20) equivalently and equivalently generates a negative impedance $-Z_0$, the value thereof is set to be $0 \leq Z_3 = Z_v - Z_0$ in such a way that said internal impedance Z_v inherent to said vibrator (20) is reduced to a value Z_3 such that the vibrator (20) and the resonator (10) be dealt with independently of each other in terms of the equivalent circuit, thus permitting to obviate the mutual dependency condition between said vibrator (20) and said resonator (10),

- the resonator (10) being tuned by adjusting the equivalent mass of the resonance radiation unit (11) so that its lowest resonance frequency (f_{op}) is set to be low to an extent where, regardless of the volume of the cabinet, super-bass reproduction with sufficient sound pressure can be obtained from the opening port when the resonator (10) is driven in such a way."

Claim 1 of the second auxiliary request differs from claim 1 of the main request only in the final feature of the characterising part:

- the resonator (10) being tuned by adjusting the air mass in the duct of the Helmholtz's resonator with the choice of the parameters defining the dimensions so

that its lowest resonance frequency (f_{op}) is set to be low to an extent where, regardless of the volume of the cabinet, sufficient acoustic radiation power can be obtained from the opening port (11) when the resonator (10) is driven in such a way."

Claim 1 of the third auxiliary request has the same preamble as claim 1 of the main request and the following characterising part:

"- said vibrator drive means (30) has a drive control means (31) and a frequency characteristics control means (f_c) for controlling a drive condition of said vibrator (20) and reducing the internal impedance inherent to said vibrator (20) equivalently and equivalently generates a negative impedance $-Z_0$, the value thereof is set to be $0 \leq Z_3 = Z_v - Z_0$ in such a way that said internal impedance Z_v inherent to said vibrator (20) is reduced to a value Z_3 such that the vibrator (20) and the resonator (10) be dealt with independently of each other in terms of the equivalent circuit, thus permitting to obviate the mutual dependency condition between said vibrator (20) and said resonator (10),

- the resonator (10) being tuned by adjusting the equivalent mass of the resonance radiation unit (11) so that its lowest resonance frequency (f_{op}) is set to be low to an extent where, regardless of the volume of the cabinet, super-bass reproduction with sufficient sound pressure can be obtained from the opening port (11) when the resonator (10) is driven in such a way."

VII. The parties' arguments are discussed in the Reasons for the Decision.

Reasons for the Decision

1. *Background to the invention*

1.1 In loudspeaker systems it is known to improve the performance by providing adjacent the sound transducer a resonant cavity, which the patent refers to as a "Helmholtz resonator". The patent is concerned with one such resonant cavity, the bass reflex box, which in its simplest form has a sound transducer forming part of one wall of the cavity and an opening to the outside world by way of a neck portion or port. The transducer radiates both directly and into the cavity, and by adjustment of the cavity volume and of the cross-section and length of the neck portion the resonant frequency can be adjusted. In the patent the sound transducer may be a known moving coil speaker but various other transducers are also described; the patent refers, as does the claim, to a "vibrator" rather than a transducer.

1.2 The problem said to be solved by the claimed invention is that of providing a good low-frequency response for a given cavity size; the patent also seeks to decouple the transducer from the cavity such that the two can be considered as separate entities and the design of one has no effect on the other.

1.3 In order to achieve this decoupling the patent considers the equivalent electrical circuit of the system comprising the transducer and cavity; Figure 1b shows the basic equivalent circuit, comprising the internal impedance of the transducer Z_v , said to consist primarily of the resistance of the voice coil in the case of a moving coil speaker, and impedances Z_1 and Z_2

respectively representing the physical characteristics of the transducer and the resonator. The impedance Z_1 is a parallel tuned circuit whilst impedance Z_2 is a series-resonant circuit. It is apparent that in such an arrangement any change in current in either Z_1 or Z_2 will necessarily influence the current in the other, i.e. a change in the physical characteristics of the transducer will influence the resonator and vice versa.

1.4 This mutual influencing is ameliorated by the provision of a driving arrangement having a negative impedance, ideally perfectly matching the internal impedance Z_v of the transducer. It will be apparent that if such a match can be achieved the equivalent circuits Z_1 and Z_2 will be fed by a constant voltage source, so that a change in one circuit will have no effect on the other circuit. In other words, by providing a negative impedance matching the transducer internal impedance, the physical characteristics of the transducer and resonator can be decoupled, allowing easier design of each.

1.5 In the patent the negative impedance is generated by means of an amplifier circuit incorporating a current proportional positive feedback loop. Although positive feedback runs the risk of giving rise to oscillation, the patent makes clear that so long as the negative impedance generated by this circuit is less than the impedance of the transducer, oscillation will not occur. In the example given in the patent, see page 10, lines 6 to 8, the preferred value of negative resistance for a transducer in the form of a speaker with a coil having an internal resistance of 8Ω is -4Ω , i.e. the compensation provided is 50%.

2. *Clarity and Interpretation of claim 1 (main request)*

2.1 The first characterising feature of claim 1 refers to drive control means which generate a negative impedance "in such a way that said internal impedance ... is reduced to a value ... such that the vibrator and the resonator be dealt with independently of each other in terms of the equivalent circuit, thus permitting to obviate the mutual dependency condition between said vibrator and said resonator".

2.2 It is apparent from the description, see page 7, line 29 to page 8, line 7 and page 9, line 53 to page 10, line 13 of the patent, that the above-mentioned condition is only fully met when the negative impedance is opposite and equal to the internal vibrator impedance; this cannot be realised in practice because of the risk of oscillation. As noted at point 1.5 above, in the preferred embodiment the compensation is 50%. The Board therefore considers that the claim should be understood as being limited to providing some, rather than full, compensation for the transducer internal impedance, the remainder of the feature stating *desiderata* rather than being of limitative effect. It is observed that if the claim were to be interpreted as requiring a negative impedance such that the "mutual dependency condition" between vibrator and resonator were obviated, such a claim would be without support in the description, which discloses only partial compensation.

2.3 The remaining feature of claim 1 requires that the resonator be tuned so that its lowest resonance frequency "is set to be low to an extent where, regardless of the volume of the cabinet, super-bass reproduction with sufficient sound pressure can be

obtained from the opening port". This passage gives rise to a number of difficulties. The description nowhere defines what is meant by a "low" resonant frequency, nor what is meant by "super-bass reproduction with sufficient sound pressure". Further uncertainty is added by the reference to the "sufficient sound pressure" being obtained "regardless of the volume of the cabinet".

2.4 The Board has sought to interpret the above expressions in the light of the description. The introduction discusses at page 3, lines 19 to 42 the characteristics of a bass reflex speaker system and with reference to Figure 32 shows how by means of a cavity resonant at a frequency below the cut-off frequency of the speaker the frequency characteristic can be expanded downwards. It is stated that the cavity resonant frequency is a function of its size, the equation for resonance being given at page 6, line 11 of the patent. It therefore appears that the reference to the "lowest resonance frequency" being "set to be low" is to be interpreted as requiring a bass reflex cabinet with a resonant frequency below the cut-off frequency of the speaker.

2.5 The remainder of the feature does not appear to the Board to be of limitative effect. The statement that "regardless of the volume of the cabinet, super-bass reproduction with sufficient sound pressure can be obtained" is a mere statement of *desiderata* of a bass reflex cabinet. It was argued by the respondent that this passage did indeed have a limitative effect; page 13, lines 32 to 38 of the description showed how good bass reproduction at a frequency of 41 Hz could be achieved with a comparatively small resonator cavity. The skilled person would understand that the dimensions specified in the description were much smaller than was

usual in the art. The claim should accordingly be interpreted as being limited to acoustic apparatus having a much smaller resonator than was usual for satisfactory super-bass reproduction. The Board is unable to accept this argument. The claim does not refer to a small cavity size and the expression "regardless of the volume of the cabinet" means - if it means anything at all - that volume is not a relevant parameter. This is clearly incorrect, see equation (1) at page 6, line 11, which shows that the resonant frequency is a function both of volume and of neck cross-section and length. It seems rather that this is a reference back to the first characterising feature, namely obviating the "mutual dependency condition" between vibrator and resonator. By this means a further degree of freedom is added to the design parameters so that for any given size of cavity design is simplified. However, the claim is directed to apparatus rather than a method of designing apparatus. The second characterising feature is accordingly interpreted as merely requiring a bass reflex system with a resonance frequency below the frequency range of the speaker.

3. *Clarity and Interpretation of claim 1 (second auxiliary request)*

3.1 The first characterising feature of claim 1 is identical to that of claim 1 of the main request; the comments at points 2.1 and 2.2 above apply equally to this claim.

3.2 The second characterising feature refers to the resonator being tuned "by adjusting the air mass in the duct of the Helmholtz's resonator with the choice of the parameters defining the dimensions". The Board understands this to mean that the resonant frequency of the resonator is tuned by adjustment of the length or

cross-section of the neck portion. This tuning is said to be carried out "so that its lowest resonance frequency is set to be low to an extent where, regardless of the volume of the cabinet, sufficient acoustic radiation power can be obtained from the opening port." As regards the expression "regardless of the volume of the cabinet" reference is directed to point 2.5 above. Similarly, the reference to the "lowest resonance frequency" being "set to be low" is for the reasons given at point 2.4 above interpreted as requiring a resonant frequency below the cut-off frequency of the speaker. As with claim 1 of the main request, the remainder of the second feature appears merely to state the *desiderata* for a bass reflex cabinet and has no limitative effect.

4. *Novelty (main request)*

4.1 In the Board's view the single most relevant document is O1, which comprises two articles discussing the parameters of loudspeaker design. These articles are a republication of articles written some ten years earlier and are described in an editor's note as a "classic discourse"; the Board understands from this that in the editor's view they constitute common general knowledge in the loudspeaker art.

4.2 O1 starts by considering the electrical equivalent circuit of the mechanical parameters of a loudspeaker and at Figure 4, page 385, shows an electrical circuit identical to that of Figure 3 of the patent. The document then analyses the frequency response of the system, based on this equivalent circuit, and concludes at page 386, right-hand column that there are three variables which determine the frequency response: the Q of the loudspeaker when connected to an amplifier, the resonant frequency of the loudspeaker box and the volume of the box. It is stated that it is possible to

achieve any desired low-frequency cut-off based on these variables. In discussing the Q of the circuit the document states on page 386, right-hand column that this can be controlled by control of the amplifier output impedance, a negative output impedance being required if a Q lower than the speaker's natural Q is necessary.

4.3 At page 387 the Q of loudspeakers of different qualities is discussed; the right-hand column states that for a cheap or medium quality loudspeaker a negative output impedance of half that of the loudspeaker resistance, ie the figure used in the patent, would reduce the resonance peak and thus improve frequency response; an even higher degree of negative impedance is mentioned, three-quarters that of the loudspeaker resistance, but there is a warning of stability problems.

4.4 O1 discloses acoustic apparatus comprising a resonator and a vibrator in the configuration commonly known as a bass reflex box and with equivalent circuits for the box and vibrator as shown in Figure 4 of O1, as well as "vibrator drive means", ie an amplifier. The first characterising feature is as shown at points 4.2 and 4.3 above known from page 386, right-hand column, which tells the skilled person to use a negative impedance in order to reduce loudspeaker Q. As noted at point 2.2 above, the closing words of the feature, "such that the vibrator and resonator be dealt with independently of each other in terms of the equivalent circuit ..." have no clear limitative effect. Moreover, since the suggested negative impedance at page 387, right-hand column of O1 is identical to that provided in the embodiment disclosed in the patent it follows that the same effect must arise both in the patent and in the prior art.

4.5 As regards the remaining feature, reference is directed to O1 at page 386, left-hand column, which indicates that at the claimed priority date the skilled person understood that one of the controllable parameters in loudspeaker design is the box resonant frequency, defined as the frequency at which the acoustic mass of the vent resonates with the acoustic capacitance of the box. Thus, the skilled person is informed that either the capacitance of the box or the acoustic mass of the vent can be varied to control the box resonant frequency. At page 390 a practical example is given of how to design a box for a given loudspeaker. The box volume is said to be assigned, ie fixed, and for a desired frequency response the vent dimensions are calculated "using the methods of the standard tests". In other words, the vent is tuned as required by the claim. Table 1 at page 388 of O1 shows examples in which the box resonant frequency is below that of the speaker. Although it was argued by the appellant that such boxes were not by any means small boxes, as has already been discussed claim 1 does not require a "small box".

4.6 The Board accordingly concludes that the subject-matter of claim 1 lacks novelty in view of the disclosure of O1.

5. *Novelty (second auxiliary request)*

5.1 Claim 1 of this request differs from that of the main request only in the language of the final feature, which requires that the resonator be tuned by adjusting the air mass in the duct of the Helmholtz's resonator, and that "sufficient acoustic radiation power" can be obtained. This merely states the same as in claim 1 of the main request in different language. The above comments apply *mutatis mutandis* to claim 1 of this request.

5.2 The subject-matter of claim 1 of the second auxiliary request accordingly lacks novelty for the same reason as claim 1 of the main request.

6. *Novelty (third auxiliary request)*

6.1 Claim 1 of this request differs from that of the main request only in that the vibrator drive means is specified as having both a drive control means and a "frequency characteristics control means"; in the course of the oral proceedings the respondent drew attention to portions of the description and drawings which supported this wording, in particular Figures 24 and 27. The feedback path shown in the centre of Figure 24 incorporated low and high pass filters which shaped the frequency response, whilst Figure 27 showed in conjunction with the amplifier a box marked "frequency characteristics control". This was a particularly advantageous feature, as could be seen from the description at page 13, lines 32 to 38, in which apparatus according to the invention was described, having a cavity with a volume of six litres as opposed to a conventional cavity which required 176 litres to achieve the same bass performance.

6.2 Be that as it may, the Board notes that all practical amplifiers have "frequency characteristics control means". The well-known bass and treble controls are examples of such control means. O1 refers at page 389, right-hand column to the use of what is referred to as "bass lift" in which the frequency response of the amplifier is tailored to improve the bass response of the loudspeaker system.

6.3 The subject-matter of claim 1 of the third auxiliary request accordingly lacks novelty.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:

M. Kiehl

P. K. J. van den Berg