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Datasheet for the decision of 7 April 2017

Case Number: T 2093/15 - 3.5.03

Application Number: 10151410.7

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Title of invention:
Passive group delay beam forming

Applicant:
Harman International Industries, Incorporated

Relevant legal provisions:
EPC Art. 83

Keyword:
Sufficiency of disclosure - (no)

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Case Number: T 2093/15 - 3.5.03

D E C I S I O N
of Technical Board of Appeal 3.5.03
of 7 April 2017

Appellant: (Applicant)	Harman International Industries, Incorporated 8500 Balboa Drive Northridge California 91329 (US)
Representative:	Bertsch, Florian Oliver Kraus & Weisert Patentanwälte PartGmbB Thomas-Wimmer-Ring 15 80539 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 3 June 2015 refusing European patent application No. 10151410.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	F. van der Voort
Members:	B. Noll
	O. Loizou

Summary of Facts and Submissions

I. This appeal is against the decision of the examining division refusing European patent application No. 10151410.7 on the ground that the application with claims of a main request or claims of one of first and second auxiliary requests did not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC).

II. In a communication pursuant to Rule 100(2) EPC, the board gave a preliminary opinion on the question of sufficient disclosure.

III. With a letter dated 3 August 2016, the appellant submitted further arguments.

IV. The appellant was summoned to oral proceedings. With a letter dated 6 March 2017, the appellant submitted further arguments.

V. Oral proceedings before the board were held on 7 April 2017.

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the set of claims of a main request filed with the letter dated 11 March 2014 or, in the alternative, the set of claims of a first or a second auxiliary request, both auxiliary requests filed with a letter dated 23 March 2015.

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

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

"A network of electronic components having an audio input and a plurality of audio outputs, the network comprising:

a plurality of stages (104a-104r), each stage having a stage input and a stage output, and including a plurality of passive components, the stage output of each stage being coupled to at least one of a plurality of loudspeakers (102) arranged in an array of a predetermined shape;

each stage being configured to add an electrical delay and magnitude attenuation, the electrical delay and magnitude attenuation being adjusted based on selection of component values of the passive components such that the plurality of loudspeakers generate a sound beam having a constant beam width along at least one dimension of the predetermined shape of the array

characterized in that the stage output of each stage is coupled to the stage input of a next stage, wherein each stage is configured to add the electrical delay and magnitude attenuation to each subsequent stage where *[sic]* each stage (104a-104r) includes an LC branch where *[sic]* at least one inductor is in series with the stage input and the stage output, and at least one capacitor is connected to the stage output in parallel with the at least one loudspeaker."

Claim 1 of the first auxiliary request differs from claim 1 of the main request in that the following features are added:

"where *[sic]* the plurality of loudspeakers includes a pair of loudspeakers connected to each stage output,

where *[sic]* the plurality of loudspeakers (102) are arranged linearly, the plurality of loudspeakers including:

at least one middle loudspeaker connected in parallel to the first stage input, the at least one middle loudspeaker positioned at a center of the linear arrangement of loudspeakers;

at least one pair of loudspeakers, each pair connected in parallel to each stage output, the pair of loudspeakers positioned on opposite sides of the at least one middle loudspeaker, each loudspeaker in the pair of loudspeakers being positioned equidistant to the center of the linear arrangement."

Claim 1 of the second auxiliary request differs from claim 1 of the first auxiliary request in that the following features is inserted in the characterising portion between "the at least one loudspeaker," and "where the plurality of loudspeakers ...":

"where *[sic]* an inductance of the at least one inductor increases as a distance of the at least one loudspeaker to which the stage output is connected from a center loudspeaker in the plurality of loudspeakers increases, *[sic]*".

VII. The following documents are referred to in this decision:

D1: WO 02/071796 A1; and

D5: D. B. Keele, "Implementation of Straight-Line and Flat-Panel Constant Beamwidth Transducer (CBT) Loudspeaker Arrays Using Signal Delays", Convention Paper 5653, 113th Convention of the Audio Engineering Society, Los Angeles, 2002, October 5-8.

Reasons for the Decision

1. The application in suit relates to the design of loudspeaker arrays for acoustic beam forming, and specifically to the design of an electric passive group delay network for a linear loudspeaker array. The purpose of the network is to drive each loudspeaker in the array by an audio signal such that a sound beam which has a constant beamwidth as a function of the frequency is produced by the loudspeaker array.

2. Constant beamwidth loudspeaker arrays were known at the claimed priority dates, see e.g. D5. This document explains the principles of constant beamwidth loudspeaker arrays in detail. More specifically, D5 discloses that a spatial acoustic response, i.e. the sound beam, of an array of loudspeakers ("drivers") has a constant beamwidth when the loudspeakers are arranged in a circular arc (Fig. 1) and each loudspeaker receives the same input signal at a dedicated respective power level. The power levels are determined on the basis of "Legendre shading". A "constant beamwidth" in the present context is understood as meaning that the sound is radiated substantially with the same polar diagram for different frequencies within the frequency range of the acoustic signal (cf. D5, Figs 17 and 18, and the present application as published (EP 2 247 120 A2), paragraphs [0005] and [0026] and claim 15).

D5 further discloses that a sound beam having a constant beamwidth can alternatively be obtained by arranging loudspeakers along a straight line ("straight-line array", cf. pages 4 to 6, section 1.3 "Delay Derived CBT Arrays"). In this case, a delay is to be additionally imposed on the audio signal fed to each loudspeaker. The delay is to be set such that the deviation in position from the circular arc of each loudspeaker is compensated for (cf. page 5, right-hand column, equation (7)). Hence, by driving each loudspeaker of a straight-line array by the same audio signal, but attenuated and delayed at each driver, a sound beam having a constant beamwidth can be obtained. It is further apparent from Fig. 2 and equation (7) that the attenuation and the delay applied to the audio signal fed to a driver are constant and, therefore, independent of the frequency of the audio signal.

3. Claim 1 of the main request seeks protection for a network of electronic components including a plurality of stages. The output of each stage is coupled to at least one of a plurality of loudspeakers arranged in an array of a predetermined shape. The network includes consecutive stages (referred to in the application as forming a "ladder network", cf. e.g. paragraphs [0008] and [0016]). Each stage includes an LC branch and is configured such that the sound beam generated by the plurality of loudspeakers has a constant beamwidth along at least one dimension of the predetermined shape of the array.

4. However, for the reasons set out below, the application does not provide an enabling disclosure for selecting the component values of the LC branches of the plurality of stages such that the desired result is

achieved, i.e. a sound beam having a constant beam width.

Fig. 2 shows a 20-element loudspeaker array 202 including twenty drivers arranged linearly and connected to a 9-stage LC ladder network 204, but does not specify the values for the L and C components.

Fig. 4 shows the 9-stage LC ladder network ("example ladder network", cf. paragraph [0026]) with each component having a specific value, together with a graph showing the cumulative delay vs. frequency as obtained after each stage, and Fig. 5 shows a corresponding graph of the cumulative attenuation vs. frequency obtained after each stage. The "example ladder network" shown in Fig. 4, however, is a single, isolated example of a specific ladder network having nine stages for a specific loudspeaker array. Claim 1, however, is not limited to any specific example, as it is worded in generic terms only ("each stage ... includes an LC branch ..." and "an array of a predetermined shape"). The above-mentioned figures do not therefore provide a generic disclosure for a ladder network having LC branches with unspecified component values in combination with a loudspeaker array of any predetermined shape such that the plurality of loudspeakers generate a sound beam having a constant beamwidth, cf. claim 1.

Fig. 6 (cf. paragraph [0029]) shows a comparison of beamwidth vs. frequency of sound beams of a 16-element group delay derived loudspeaker array and a straight-line loudspeaker array (without delay compensation). However, no values of components of a ladder network by which the curve may be achieved are disclosed.

Fig. 7 (cf. paragraphs [0030] to [0032]) shows a comparison of beamwidth vs. frequency of sound beams of two 16-element group delay loudspeaker arrays "having delay networks with different component values". Again, no component values are mentioned.

Nor does any other part of the description provide an enabling disclosure for selecting appropriate component values of the LC branches for the claimed network.

5. The appellant argued that the application disclosed that a ladder network was capable of generating a constant beamwidth using simple and cheap analogue network components. Starting from the ladder network and the component values shown in Fig. 4, the skilled person would be able to optimise the ladder network circuit towards a desired sound beam characteristic. In particular, the skilled person would be taught by the parameter values as specified in Fig. 4 that corresponding components of subsequent stages of the network should be either the same or similar in value. The optimisation itself would not involve any particular difficulty for the skilled person, since it would merely require the use of a standard computer program for electric circuit calculation and circuit parameter optimisation. The skilled person would be able to instruct the program to calculate the delay and attenuation at each stage of the network and the resulting characteristic of the sound beam as a function of the frequency, and to vary the values of the L and C components of the stages of the network such as to arrive at the desired sound beam characteristic. Carrying out these steps of the optimisation process would thus only require the exercise of ordinary skills of the skilled person, which would not go beyond common general knowledge and,

consequently, would not require any further particular explanation in the application.

6. The board does not agree. The board does not contest that, for a given ladder network, i.e. with known values for the L and C components, and a given loudspeaker array, the skilled person would be able without undue effort to calculate the amplitude and delay characteristics as well as the frequency characteristics of the resulting sound beam. However, this is not the issue here. What matters is that the skilled person would not be able without undue effort to do so the other way around, as claim 1 requires, namely to design the ladder network by calculating component values of the ladder network starting out from the result to be achieved, i.e. a sound beam having a constant beamwidth along at least one dimension of the predetermined shape of the loudspeaker array. In this respect, the board notes that, since the impedances of the L and C components in each stage are inherently frequency-dependent, the delay and attenuation imposed by each stage of the claimed network are inherently frequency-dependent. This would go against the principles disclosed in D5 according to which a constant beam width is obtained by a constant signal attenuation and constant delay at each stage (see point 2 above and D5, page 5, Fig. 2 and equation (7)). Further, modifying the attenuation and delay at a particular stage would also modify the attenuation and delay at subsequent stages. Therefore, the selection of parameters for the components of the ladder network requires a complex optimisation process. The application does not provide any teaching or guidance for carrying out this optimisation. The skilled person would therefore be forced to attempt to find out,

solely by trial and error, the sets of component values necessary for obtaining the desired sound beam.

7. For the above reasons, the application does not disclose the network of claim 1 of the main request in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC).

8. The above objection applies, mutatis mutandis, to the invention as claimed in claim 1 of each of the first and second auxiliary requests. On neither of those requests has the appellant presented any arguments other than those submitted in respect of the main request.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

G. Rauh F. van der Voort

Decision electronically authenticated