The Loudness Level in the Free Field, and the Hearing Threshold in the Free Field and in the Pressure Field of Pure Tones at Frequencies below 1 kHz

Watanabe, Toshio; Møller, Henrik

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1—P—3 *周波数１ＫＨｚ以下の純音による自由音場におけるラウドネスレベル、並びに自由音場と圧力音場における最小可聴閾

○渡辺敏夫（福島高専）
△Henrik Møller(Aalborg Univ.)

1. Introduction Contours of equal loudness and hearing thresholds have been given by several researchers. The result of Robinson and Dadson was adopted as ISO/R226 in 1961. The equal loudnesses were measured by the same method [1] but they were not the same as ISO/R226. On the other hand, hearing thresholds at low frequencies have been measured by the headphone method and the pressure cabinet method at frequencies down to 2Hz. The thresholds whose frequencies are between 20Hz and 100Hz also have been given under the free field. But they are not coincidental.

In this paper the experiments were carried out to get loudness levels and hearing thresholds in the free field at frequencies below 1KHz, and hearing thresholds in the pressure field at frequencies below 125Hz

2. Test room The anechoic room and the infrasound test chamber at Aalborg University were used. They were newly constructed in August 1987. The dimension of the anechoic room is 604cmx484cmx564cm and the dimension of the infrasound test chamber is 230 cmx260cmx240cm. The background noise was very low in both rooms.

3. Loudspeakers (a)Anechoic room-This study was to directly compare a reference tone, - 1KHz tone of a fixed sound pressure, - with a variable tone to get loudness levels. So high sound pressures were required at low frequencies. Eight loudspeakers were used to generate high sound pressures. They were mounted to two enclosures whose dimensions were 785mmx785mmx420mm(D) and they were placed side by side.
(b)Infrasound test chamber - Forty - eight loudspeakers were installed on three walls. Each wall had sixteen loudspeakers which were installed in four rows of four.

4. Experiments (a)Loudness levels - A personal computer was connected with a sine generator, an attenuator and an answering box. The attenuator had a on-off switch and gave the attenuation 1dB step from 0dB to 127dB. Both of them could be controlled by the computer (Fig.1). A subject sat on a chair facing the loudspeakers in the anechoic room. As a curtain was hung between a subject and the loudspeakers, the subject didn't see the loudspeakers. So the subject could easily concentrate to hear the sound without any disturbances. The distance between the subject and the loudspeakers was 2m. A pair of tones, a variable tone and a reference tone were alternately presented. The method of limits was adopted. For the result of one loudness level, eleven trials were carried out and the mean value of the last 10 trials was the point of subjective equality.

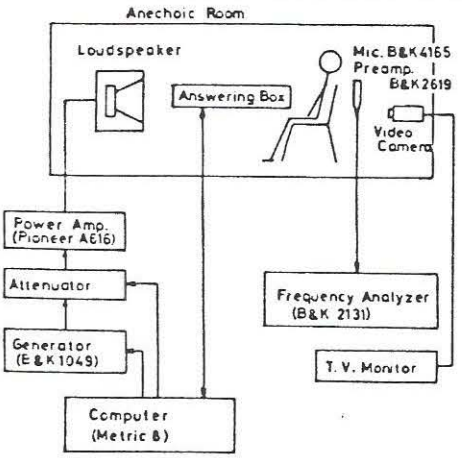

Fig.1 Schematic diagram of the experiment.

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By Toshio Watanabe (Fukushima National College of Technology) and Henrik Møller (Aalborg University)

(b)Hearing thresholds - The apparatuses and the room for the measurement of the hearing thresholds in the free field were exactly the same as they were for the measurement of loudnesses. For the measurement of the hearing thresholds in the presser field they were almost the same as they were in the free field except for the power amplifier, the loudpeaker, the microphone and the preamplifier of the microphone. The psychometric method was the method of limits. For one frequency, eight trials were carried out and the average of eight trials was the value of the hearing threshold.

Twelve persons were used as the subjects for both experiments. There were five females and seven males, between the ages of eighteen and thirty.

5.Results The hearing thresholds in the free field and the loudness contours are shown in Fig.2. This shows the ISO/R226 and the results of Fletcher and Munson, too. The hearing thresholds in the pressure field are shown in Fig.3. This diagram shows the hearing threshold in the free field and the MAF of ISO/R226. In Fig.2, the MAF of R226 is very close to the present study but the loudnesses of the present study are very different from R226. They are similar to the Fletcher and Munson's results rather than R226. In Fig.3, The hearing thresholds in the free field are very close to them in the pressure field. The results in the pressure field are 1～2dB greater than in the free field from 50Hz and below.

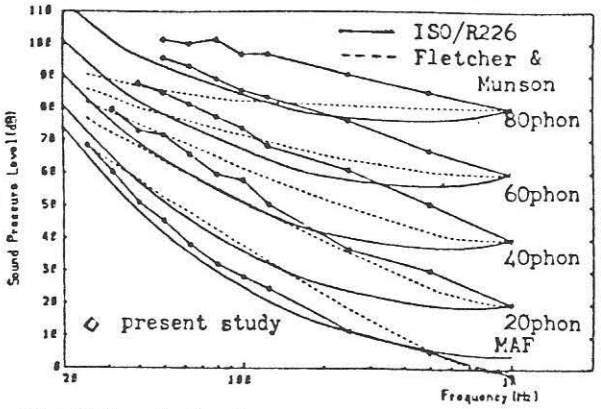

Fig.2 Equal-loudness contours

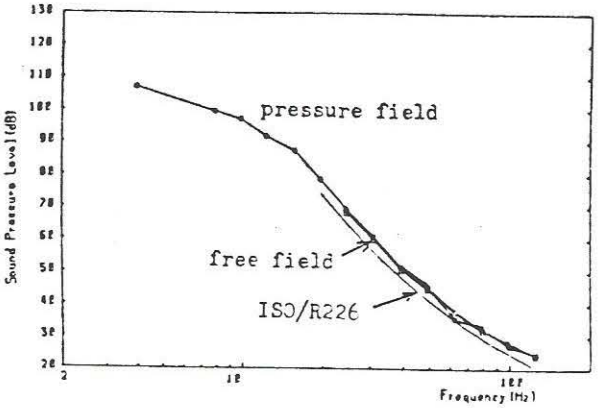

Fig.3 Binaural hearing thresholds

6.Discussion The loudness levels given by this study are much greater than R226. In this study very accurate experiments were carried out. So it could be considered that the discrepancies do not come from the experimental condition or the sound condition but from the psychometric condition.

The discrepancies of the hearing thresholds between the pressure field and the free field were checked by the head and torso simulator - B&K Type 4128. The ear simulator B&K Type 4157 was mounted to it. Then these were cleared up.

7.Conclusions The loudness contours of 20 phon, 40 phon, 60 phon and 80 phon were determined at frequencies below 1KHz. They were almost straight lines and much greater than R226. The hearing thresholds in the pressure field were 1～2dB grater than in the pressure field at frequencies between 25Hz and 50Hz. It was found that this difference comes from the sound received in the human ear in both the pressure field and the free field.

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Reference

(1) H. Møller and J. Andressen: Loudness of pure tones at low and infrasonic frequencies, J. Low Frequency Noise and Vibration, vol.3. No.2 78-87(1984)