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ACOUSTICS OF THE OPEN PLAN

The sound pressure level distribution within large enclosures

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1. Introduction

It is usual to consider the sound field in a room as being made up of two parts, the direct field and the reverberant field. The direct field is in general equal to the one that would have resulted under free field conditions.
The reverberant sound field originates out of sound that is once ore more times reflected and is thought to be homogeneous and isotropic.
It proves that this representation of the sound field is only true in extreme cases e.g. in small and very reverberant rooms.
As there is not, as yet, a consistent theory of the sound distribution in a room, we tried to find experimentally which factors determine the sound distribution.

2. Measuring technique

In as many rooms as possible sound pressure levels were measured as a function of the distance to a "point source". In most cases this was done at discrete distances, but in some cases the sound level was continuously recorded in dependance of the distance. A bandwidth of at least one octave of filtered white noise and a really omnidirectional point source with a flat frequency response were needed to avoid interference patterns. Only then one gets smooth attenuation curves. After experimenting with many types of "non directional" sources, the best results were obtained with a 250 mm long tube, diameter 20 mm on a driver system for a hornloudspeaker.

The tube itself was filled with glaswool to damp the tube resonances.
The microphone was a 12,5 mm B. & K. or Sennheiser omnidirectional condensor microphone.

3. Results

In all rectangular rooms the sound pressure level decreased with distance not only near to the source but continued to decrease further on, although mostly at a lower rate.
If the dimensions of the room are of the same order of magnitude, the sound pressure level at large distances is a power function of the distance to the source. The attenuation per doubling of the distance proves to be a function of the floor area, the height of the room and the measured reverberation time τ_m as shown in fig. 1.
In an in one direction large room, as is a corridor, the sound energy density was found to decrease not according to a power function, but according to an exponential function of the distance.
In a "flat" room as is an open plan office, the sound energy expands- after a first spherical expansion- cylindrical. This responds to a 3 dB- near to the source 6 dB-attenuation rate. Here upon an exponential decrease is superimposed. (fig. 2).
At the walls reflection takes place. This results in a lessened attenuation rate near to the walls, that becomes more or less an equal attenuation per distance doubling.
In an open plan office one finds thus a sound attenuation versus distance as is given in fig. 3.
In a smaller room one is probably everywhere near to the wall.
In almost all rooms the sound field is only very near to the wall more or less isotropic. At all other places the largest part of the intensity is coming from the direction of the source as can be concluded out of the effect of screens (fig. 4).

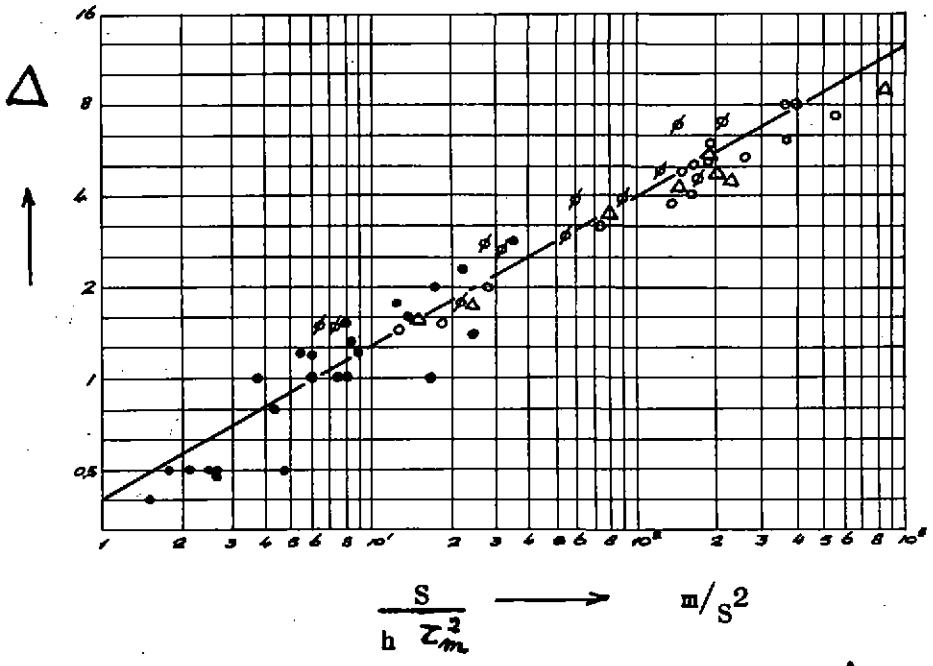

fig. 1 The attenuation per doubling of distance Δ to the floor area S over the height h times the square of the measured reverberation time τ_m

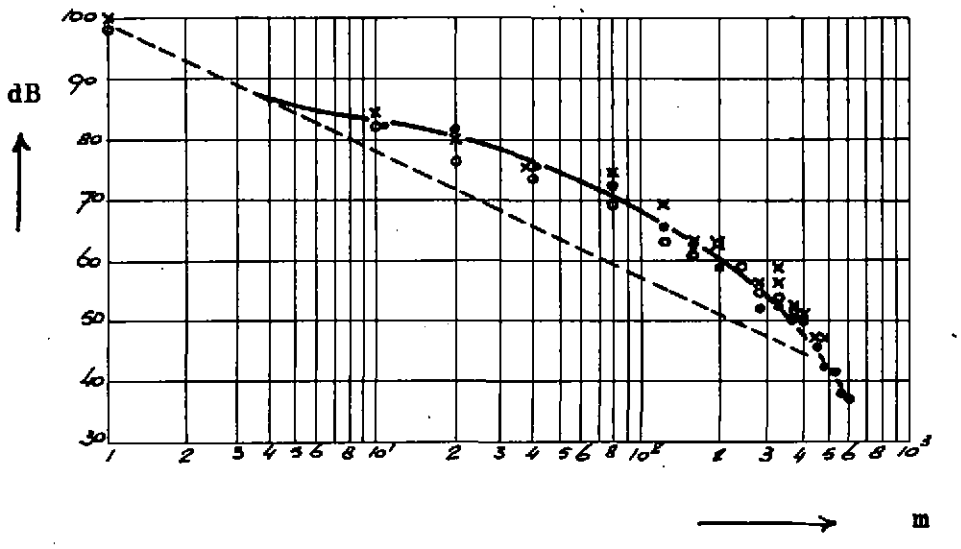

fig. 2 The attenuation versus distance in different directions in a very large open plan office (ca 7000 sq meter)

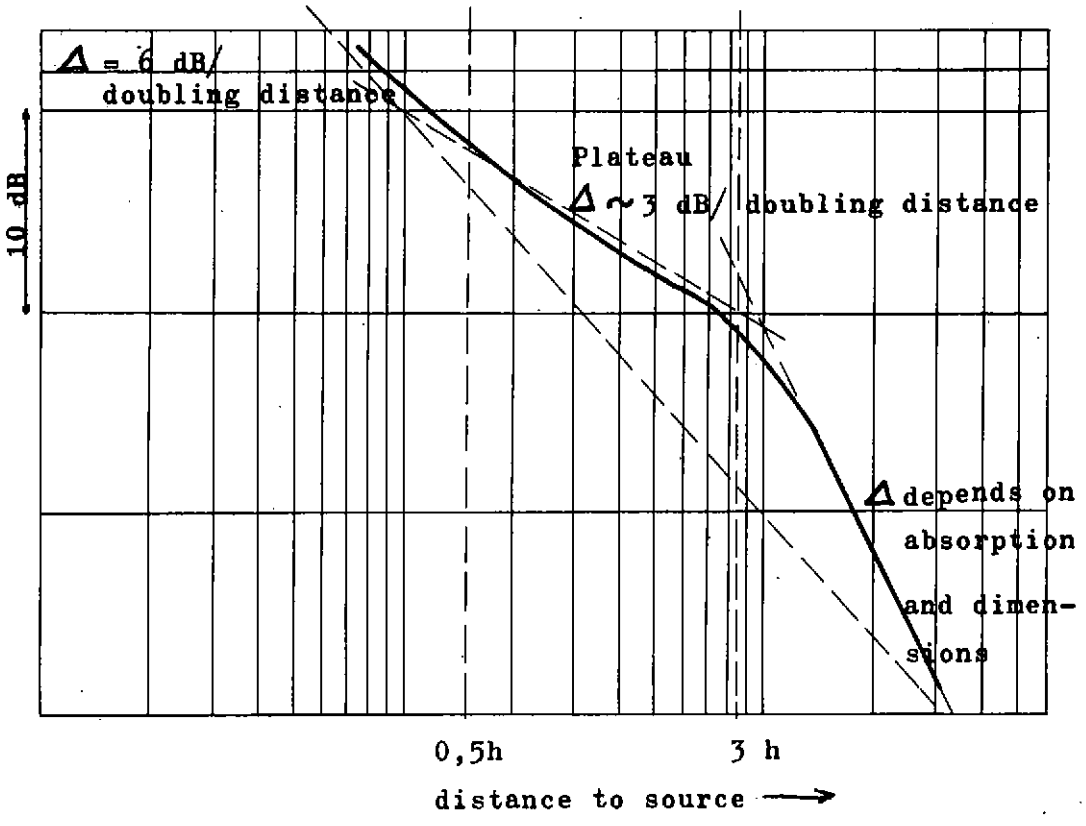

fig. 3 The relative soundpressure level versus the distance to the source in an "open plan office" with height h

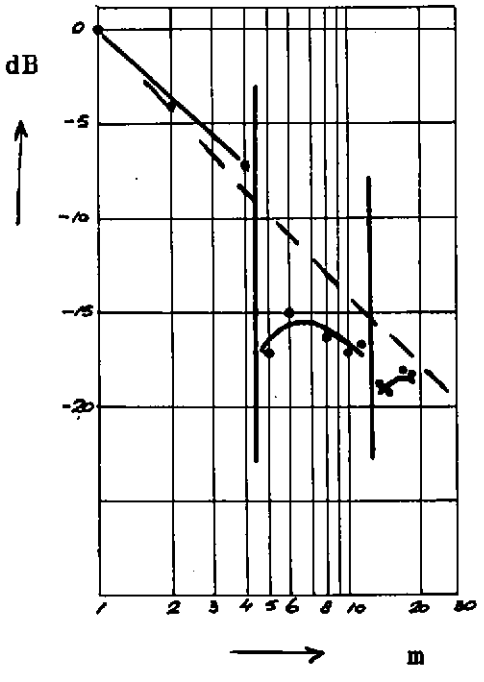

fig. 4 The relative soundpressure level versus the distance to the source if two screens (height 1,6 m, at distance 4,2 m and 13 m) are placed in the line of measurement.
The broken line gives the results without screens.