Concert hall acoustics

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Introduction

To improve our knowledge about relevant criteria for good concert halls we followed different orchestras on tour in Europe and the U.S.A.
By judging recordings, listening during the tours and discussions with musicians we were able to appreciate the influence of the concert hall acoustics on the same music in different halls. Combined with our own experiences as consultants of concert halls we tried to relate the subjective appreciation of the acoustics of the different halls by listeners or by musicians to consequences for the design of a hall. In this paper we report our first and more or less personal evaluation and the consequences for our acoustics consulting for new to build halls. During the next year we will evaluate the recordings with listening groups to get statistically reliable results.

Criteria for listeners

Generally the first point in concert hall acoustics judgement concerns the quality of the reverberation. Our findings i.e. that some halls with reverberation time between 1.8 and 2.4 s were found to be satisfactory, whereas others were not, lead us to believe that the precise choice in it itself is not so critical, but is related to the other criteria to be discussed.
Another important point noticed while listening to the (calibrated) recordings is the sound level. One appreciates only a few dB difference as a totally different sound. The final judgement about the preferred level depends (of course) upon the music. We followed the

Orchestra of the 18th Century with their authentic instruments to the Amsterdam Concertgebouw (19.000 m^3) and the Vienna Musikvereinssaal (15.000 m^3).

Every one prefers the louder Musikvereinssaal or even smaller concert halls such as the Vereeniging Nijmegen (12.000 m^3) or Casino Basel (10.000 m^3) See also figure 1. For a Mahler symphony the Amsterdam Concertgebouw is perfect and the smaller halls are too loud.

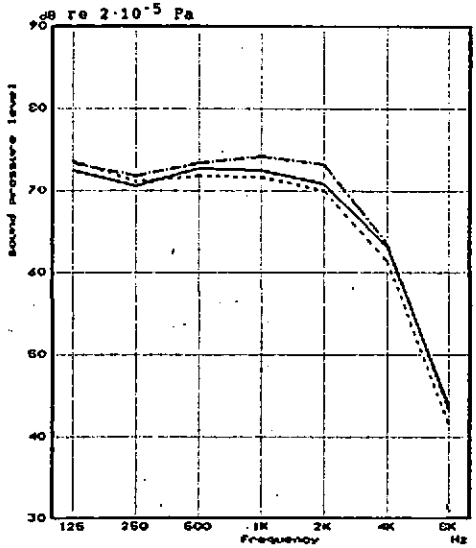


figure 1: Sound levels during the first part Eroica by the orchestra of the 18th Century.

Another point is the precision or clarity of the sound. This precision depends on several factors. First of all halls with a very long reverberation are less precise than halls with a short reverberation. Among halls with a certain reverberation time, there is however still an important variation in the clarity.

From our listening experiences we learned that for the public this clarity depends for a very large part on the reflections of the "stage" sound by ceiling and side walls. One can distinguish between halls with a special orchestra area with a reflective lowered ceiling and reflective walls surrounding the orchestra (e.g. Gulbenkian hall Lisbon or Salle Pleyel Paris, figure 2), and halls where the orchestra is placed in such a way that their experience is to be fully in the hall (e.g. Amsterdam, figure 3). In general the musicians prefer the first type of hall. It seems to create an easier ensemble. Relistening the sound recorded on the stage on a dummy head we had the impression of a stronger reverberation than in the other type of hall. But it reinforces also the direct sound (including the first reflections) of the orchestra and so the clarity. The conductor and often also the soloïsts however prefer to hear the final result of their efforts and to be in the middle of the acoustical volume of the hall.

For symphony halls we consulted we chose - as a solution for this dilemma - to create a determined orchestra area enclosed up to a certain height with side walls and a rear wall but with audience around the orchestra on the level of the first balcony (see also the paper by Metkemeijer on the newly built Dr. Anton Philipszaal in The Hague). The result is a good clarity combined with a relatively long reverberation time. Also a promising trial rehearsal at a new concert hall based on the same ideas in the eastern part of Holland (Enschede) has taken place.

Another point that influences the clarity, especially of the instruments in the middle of the orchestra as we learned installing them during a concert, is the application of risers. The choise of risers also depends on the music and the interpretation of the conductor.

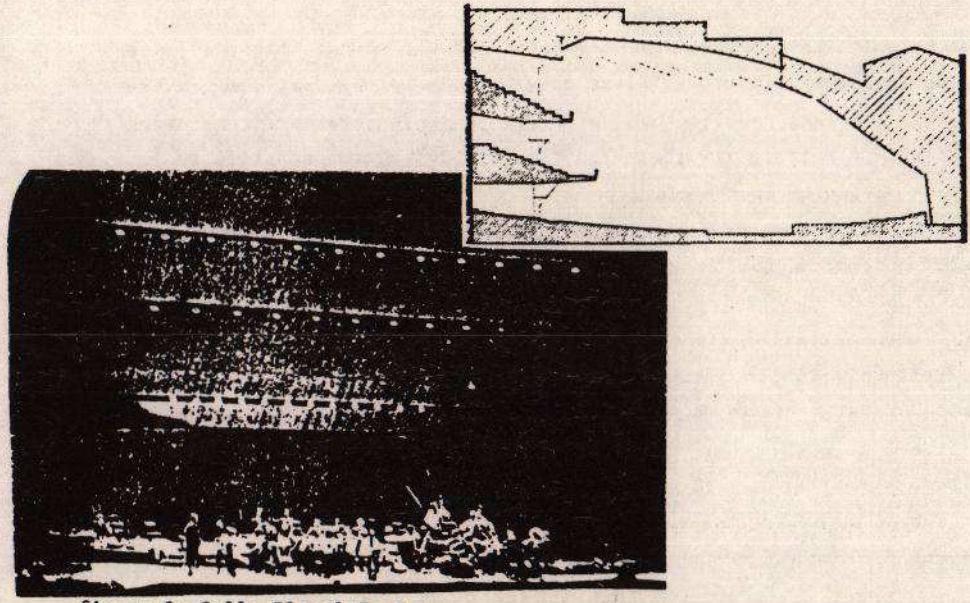


figure 2: Salle Pleyel Paris

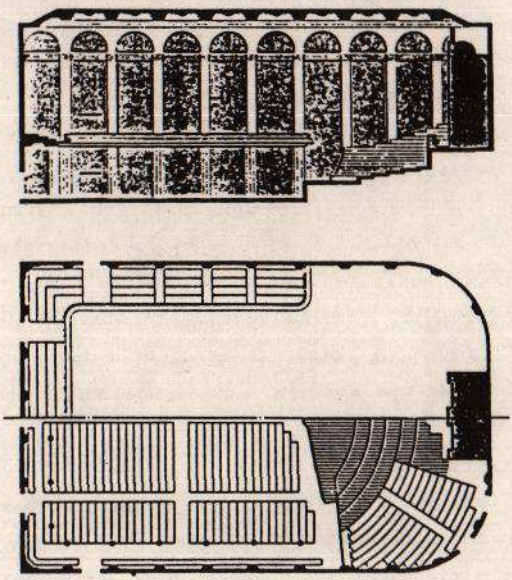


figure 3: Concertgebouw Amsterdam

Clarity and precision and the sense of reverberation are directly related to the proportion direct sound to reverberant sound. So this proportion is decisive for the acoustics of a hall.
Futhermore experience during the tours strengthened our preference for a "frontal" hall (e.g. the shoe box type) as the sound quality over the hall is as homogeneous as possible because this proportion is relatively constant. For central halls this proportion is less constant i.a. due to the directivity of certain musical instruments.

The final touch of the acoustics in a hall is in our opinion created by the first reflections. These are created in the stage area by walls behind or beside the orchestra and the side walls and ceiling of the hall. We know that especially the string tones are influenced by the latest reflections. However we are aware of the possible drawbacks of the side or rear walls around the stage. A wall too close to the horns or percussion can create a sharp sound or unwanted interferences with the tympani. This influence can be reduced by diffusion on these walls.

From our tours we conclude that the volume of a concert hall for a symphonic orchestra of 70-100 persons should preferably be about 20.000 m^3 but at least 10.000 m^3. The coupling of the orchestra space with the auditorium should be as good as possible. In preference one should place the orchestra in such a way that the stage and auditory area are one volume. An orchestra volume as coupled space should be avoided. Some reinforcement at least by side wall reflections is preferred by the musicians. The final choice of the reverberation time should be made as a function of the total volume of the hall and the reinforcement of the direct sound be early reflections, but it has to be around 2 s.

Variable acoustics

Armed with our knowledge about a minimum volume needed for a concert hall we had to face the problem of the demand for variable acoustics for medium sized theatres in view of a variation between concert hall and theatre. The auditorium part of a theatre is normally about 4.000 m^3. We need at least 10.000 m^3 for concerts. Useful volume for the orchestra sound, that is normally not used in a theatre, can be found in the stage area and the void over a false ceiling in the hall itself. We decided to use this space by suppressing the false ceiling and installing a movable reflector and curtains as variable absorption and volume in the auditorium space, and by the creation of a much wider and higher constructive stage opening than usual. The stage volume is opened by double retraction of the fire screen and by moving the proscenium bridge upwards and the proscenium towers sidewards.

After installing movable partitions in front of the side- and backstages, and reflectors under the fly tower one obtains a shoe-box shaped concert hall with a volume of 10.000 m^3 instead of a theatre of 5.000 m^3.

By an appropiate choice of the side wall diffusion (and reflection!) we got the results we wanted. The variation in reverberation times reached is shown in figure 4. The theatre situation is the one with for speech intelligibility favourable short reverberation time obtained by lowering retractable curtains as absorption and installing a reflector for reinforcing the speech. Already two theatres of this type in the Netherlands (Venlo en Drachten) are realised. A third theatre of this kind in Maastricht is in the stage of designing.

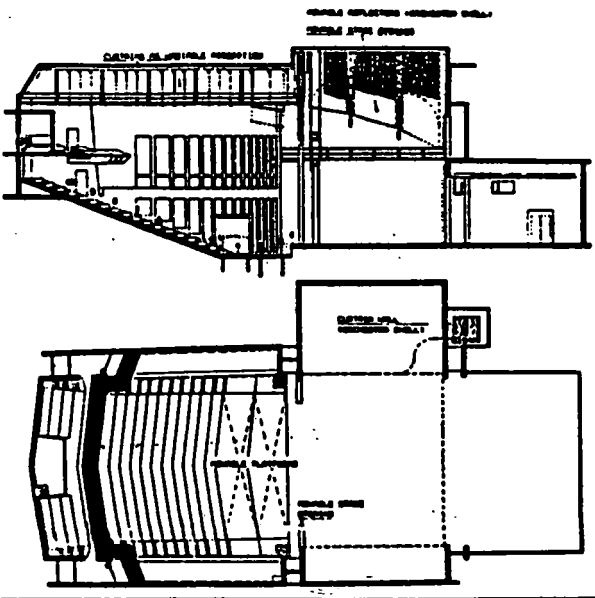
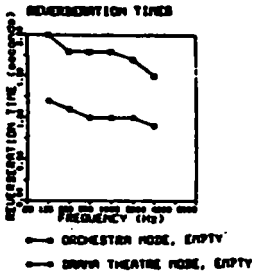


figure 4a
"Maaspoort" Venlo



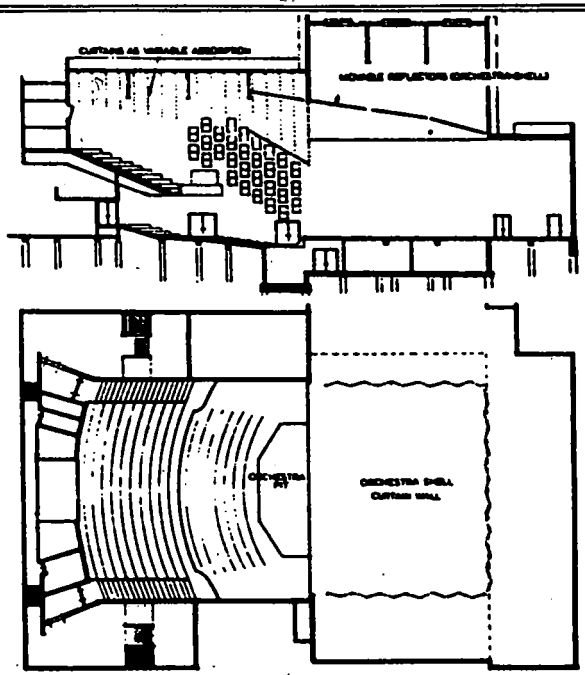


figure 4b
"De Lawei" Drachten