19th INTERNATIONAL CONGRESS ON ACOUSTICS
MADRID, 2-7 SEPTEMBER 2007

ACOUSTICAL DEMANDS FOR THE CONDUCTOR'S LOCATION

PACS: 43.55.Gx

MEYER, Jürgen
Bergiusstraße 2a, Braunschweig, D-38116, Germany; juergen.meyer-bs@t-online.de

ABSTRACT
Among the responsibility of a conductor standing in front of an orchestra, three points place special demands on the room-acoustical conditions at his location: the control of a homogeneous sound of the individual string groups, the dynamic balance between different instrument sections, and the spaciousness of the full sound to be expected in the audience area. Whereas the listeners' loudness impression mainly is determined by the diffuse field level in the hall, the conductor's loudness impression depends mainly on the direct sound and may be additionally influenced by early reflections coming from the walls around the orchestra and from above. Because of the different distances between the individual string players and the conductor, his assessment of the homogenity of the string sections' sound can effectively be supported by lateral reflections of sufaces close to the players, whereas reflections from more distant walls or from above have only a rather small importance. On the other hand, reflections from above improve the control of the dynamic balance between the strings and the different wind groups. Spatial impression generally is perceived only in the frontal hemisphere; that leads to problems for the conductor when assessing the spatial impression in the audience area. As he hears in the horizontal plane predominantly the direct sound of the orchestra, he perceives a spatial sensation only from the space above his location or from higher room sections behind the orchestra.

INTRODUCTION
Since more than hundred years, concert hall acoustics is concerned with the sound transmission from the orchestra to the audience and with the sound-aethtetic evaluation of the listeners' sound impression. At first, the reverberation time was the centre of attention, lateron further criteria were included in the research decribing the temporal fine structure of the sound field in the audience area. In this connection, particular importance was attached to the spatial impression that enables the "blooming up" of the sound when becoming louder; it contributes essentially to the subjective impression of the musical dynamics.

Since about thirty years, the sound field in the stage area has been taken into account, mainly under the aspect of the mutual hearing of the instrumental players – more exaxtly said, the balance between the loudness of the musician's own instrument and the other orchestral parts. For, if a musician hears his own instrument rather loudly, but the other ones too soft, the rhythmic precision is impaired whereas - on the basis of the harmonic background - a correct intonation is possible. On the other hand, if a musician hears his own instrument too softly, the intonation as well as the refinements of the articulation are impaired whereas a correct rhythmic precision is yet possible because it is mainly generated by the fine-motion of the playing technique and does not need a rather precise sound impression of the own instrument. That means that the evaluation of the sound field in the stage area is made not by sound-aesthetic aspects but by the demands of playing technique.

Nearly nothing is decribed in the literature about the acoustics of the conductor's location till now even though his situation is a distinctive feature when standing in front of an orchestra: it combines sound-aestetic aspects as well as aspects of the performance technique. For, the musical task of the conductor comprises the overall responsibility for the tonal shape received by the audience. In detail, this includes:

- The decision of the the number of players of the string sections and the seating arrangement of the strings
- The decision of the musical *tempi* and the control of the rhythmic connections
- Aspects of sound quality such as timbre and character of onsets and the total sound of the individual string groups
- The dynamic development as a whole
- The dynamic balance between individual instrument groups, particularly between strings and winds
- The control of the intonation (however, this point concerns only the rehearsals as the conductor has not any influence on the intonation during the performances)

For some of these points there exists a more or less strong dependence of the conductors situation on the acoustics of the ambient room. In the following, three of them shall be explained in detail, with regard to the other ones, the comprehensive literature may be recommended [1].

THE TOTAL SOUND OF THE STRING GROUPS

A homogeneous sound of the different string parts is a focal point of an orchestra's tonal quality. Therefore it is an important task for the conductor to watch over an uniform fine-structure of the playing technique, particularly of the articulation. This requires an acoustic ambience that enables the conductor to hear all players of a string group in an appropriate manner. But the different distances between the individual players and the conductor lead to problems with regard to the direct sound reaching his ears. Figure 1 shows the different delay times and levels of the sound arriving at the conductors location and at a typical audience seat (i. e. outside the triple diffus-field distance); reference is the level of the first desk (= 0 dB).

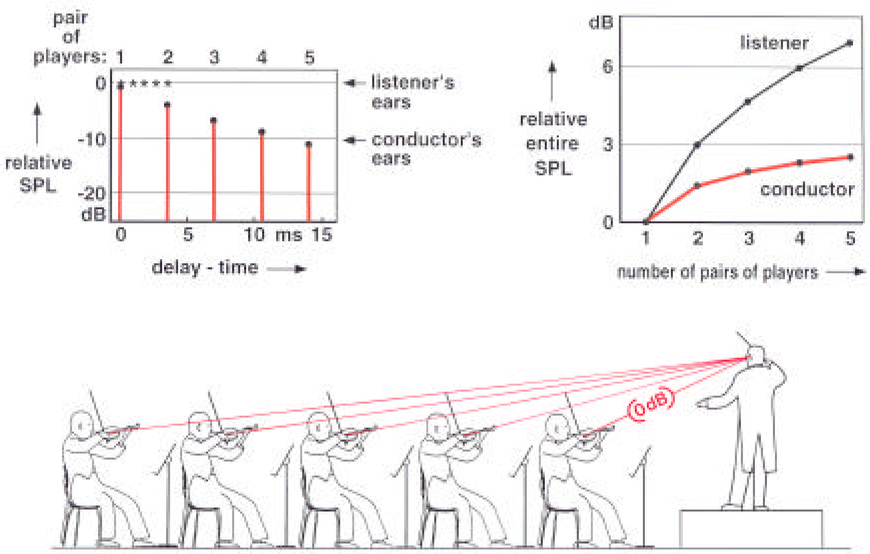

Figure 1.- Direct sound from the individual desks of a violin group to conductor and audience

As the left diagram illustrates, the direct sound reaches the conductor spread over about 15 ms and attenuated up to 15 dB whereas for the audience the sound from all players has nearly no different delay times and the same level – under the condition that all players play with the same intensity. The right diagram gives an impression of the loudness to be expected by summing up the level for an increasing number of players. The graph line for the conductor's position shows that the entire level is predominantly produced by the first three desks, adding the 4^{th} and 5^{th} desk enlarges the level only by less than 0.4 dB each, i. e. it is not audible. For the audience, even adding the 5^{th} desk leads to an increase of the entire level by about 1 dB. This situation that might be found in open air space or extremely dry studio rooms, is very unsatisfactory for the conductor and indicates the necessity to improve his acoustic situation by specific reflections.

Therefore in Figure 2, the influence of a reflecting wall positioned just behind the violin group and of a reflecting ceiling having a height of 8 m above the podium is shown assuming plane and non-absorbing surfaces. Because of the small distance between the back players and the wall, the reflections adjoin the direct sound; the reflected sound from the back desk reaches the conductor first and consequently as the strongest one, whereas the reflection from the front desk is weaker by 4 dB (green lines). The reflections coming from the ceiling in quick succession are delayed by more than 30 dB (blue lines); because of this delay, they cannot effectively support the rhythmic connections. But for the loudness impression of the violin group, the reflections coming from areas close to the orchestra certainly play a role.

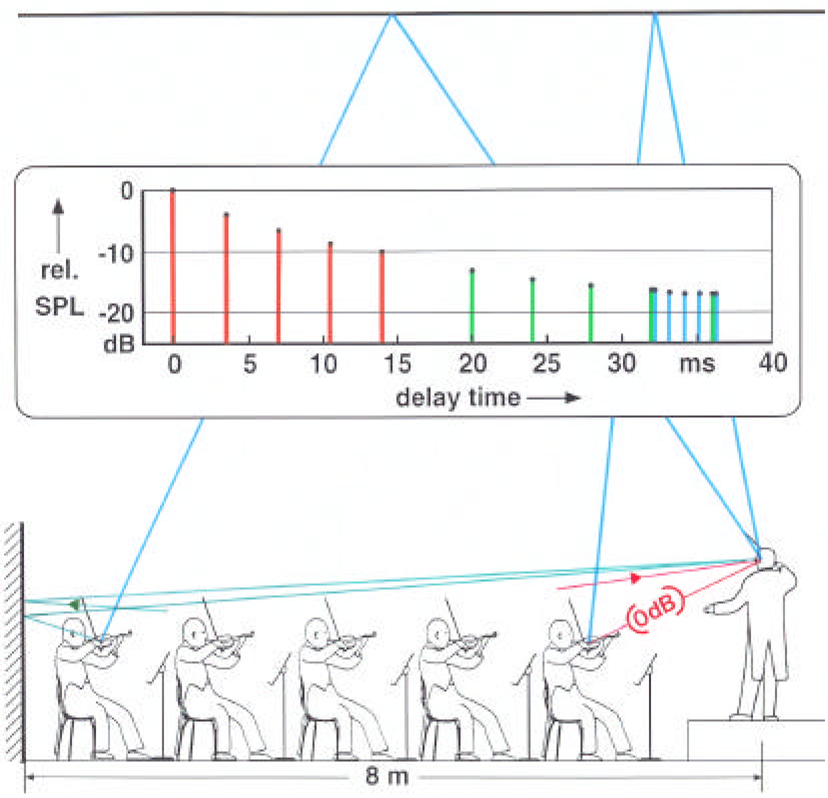

Figure 2.- Effect of a wall and a ceiling reflection on the sound field at the conductor's location

In addition to the situation shown in Figure 2, the relative sound pressure level generated by the individual desks is illustrated in Figure 3. The diagram demonstrates the influence of one to three wall reflections caused by areas close to the orchestra and of a ceiling reflection on the conductor's loudness impression.

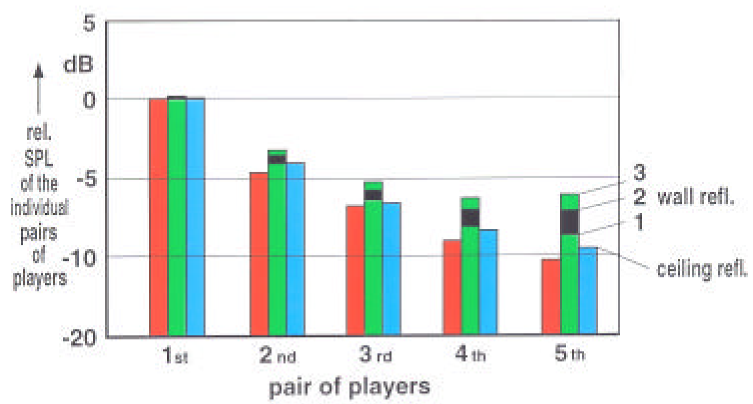

Figure 3.- Increase of the SPL at the conductor's location caused by wall and ceiling reflections

Compared with the direct sound, the level including a ceiling reflection is barely higher, even for the back desks. But just one wall reflection has a stronger effect; even the level generated by the back desk reaches a level that lies clearly less than 10 dB below the level of the front desk. Considering that the masked threshold for sounds having the same frequency but coming from incoherent sources lies in the order of –10 dB (related to the stronger one of both sounds) one can conclude that even by this single reflection, the sound of the back desks might not be totally masked for the conductor and therefore can contribute to his impression of the total sound of the violin group. If two or three wall reflections (from areas close to the orchestra) reach the conductor, the level difference between the individual desks is reduced to about 6 dB enabling the conductor much better to control the homogeneity of the group.

DYNAMIC BALANCE BETWEEN DIFFERENT INSTRUMENT SECTIONS

For the conductor, it is even more complicated to assess the loudness of different instruments or instrument groups as it is felt by the audience. For a listener in the hall, the loudness is almost only determined by the diffuse sound field, i. e. by the sound power radiated from the individual instruments, direct sound and first reflections play only a secondary role. By contrast, the loudness impression of the conductor is predominantly caused by the direct sound as the distance to most instruments is smaller than the single or at least the double diffuse field distance. As that leads to a higher degree of clarity, an influence of the kind of articulation on the subjective loudness impression cannnot be rules out. In this connection it has to be considered that for the strength of the direct sound at the conductor's ears, not only the different distances of the instruments but particularly the directivity of their sound radiation plays an essential role [1].

This situation shall be illustrated by Figure 4. Above a cross section of an orchestral podium, there are listed the distances of the individual instruments to the conductor and the level differences caused by these distances (related to the front desk of the violins). In the third and fourth lines, the typical sound power level of the instruments when playing *forte*, and the directivity index for the strongest harmonics (for the direction that is orientated towards the conductor) are given. As result from these conditions, the bottom line shows the sound pressure level occuring at the conductor's ears.

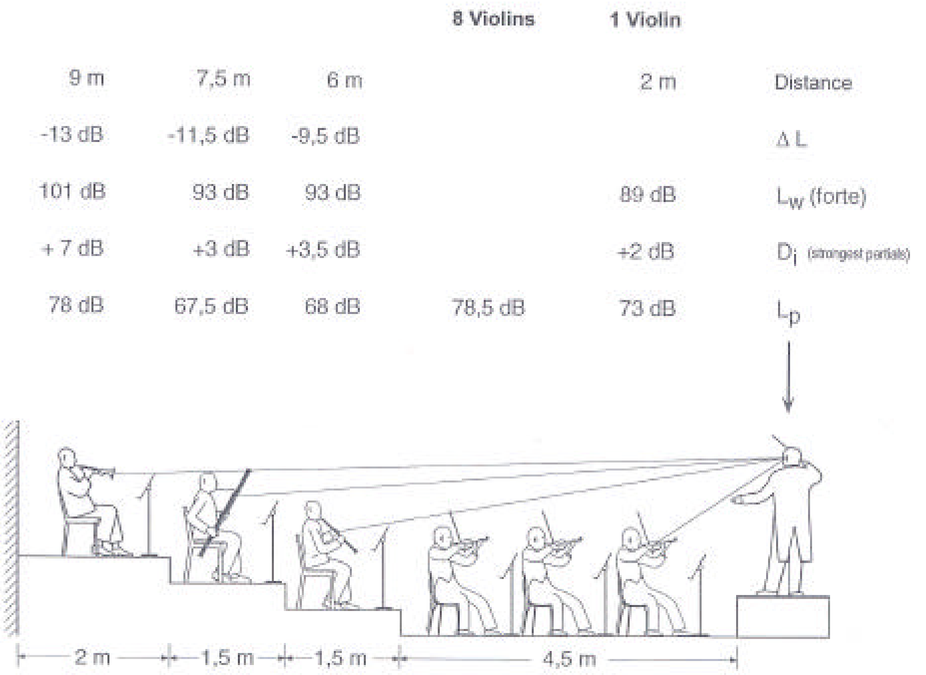

Figure 4.- Sound pressure level L_p of the direct sound at the conductor's ears derived from distance and related level attenuation ?L, sound power level L_w and directivity index D_i

For example at the condutor's location, a single violin effects a sound pressure level of 73 dB, whereas the woodwinds reach only values about 68 dB and a trumpet about 78 dB like a violin group of 8 players. Consequently for the conductor, a woodwind seems to be softer by 5 dB than a single violin or by 10 dB than the violin group, but a trumpet seems to be louder by 5 dB than a single violin or just as loud as the violin group (if they all play a typical *forte*).

For the listeners, there occur quite different loudness ratios because their loudness impression – as mentioned – is determined mainly by the sound power ratios (3rd line from above). In this connection may be reminded that 8 violins produce a sound power level which is higher by 9 dB than that one of a single violin. Consequently for a listener, the oboe or basson seems to be louder by 4 dB than a single violin and softer by 5 dB than the violin group. Or a trumpet is louder by 12 dB than a violin or by 3 dB than the violin group. As a result, the conductor assesses – in the case of a orchestral seating like in the drawing – the loudness of the woodwinds being to soft by about 5 dB and even the trumpet being to soft by about 3 dB in comparison with the loudness ratio felt by the audience.

Generally, these relations are valid for all dynamic levels, but there is an additional influence of the sound spectra that are varied with different instruments in a different way when changing the dynamics. Particularly, the high frequency components increase much more with the wind instruments than with the strings if the overall loudness increases. As these high components have a stronger directivity than the lower harmonics, the winds seem to be less concentrated when playing *piano* and the dynamic differences are felt to be enlarged for the players as well as for the conductor. On the other hand, the stringed instruments vary their sound spectrum rather less and produce – even in *piano* – a spectrum rich in overtones. Therefore once more, for the conductor they seem to be relatively loud in comparison with the winds, maybe even in a stronger degree than in *forte*.

Sound reflections from a rear wall reduce these problems not much because of the directivity of the winds – except for the horns. Reflecting areas above the orchestra may steer the sound of the higher strings towards the conductor as these instruments radiate the higher frequency components rather strongly upwards. At least a partial equalization between the sound of the winds and the strings can be effected by reflecting areas positioned above the winds if these reflectors are orientated in such way that the sound of the winds is steered towards the conductor (and the front area of the audience). Such reflectors can also be very helpfull in rehearsal rooms to improve the impression of the dynamic balance between the instrument groups.

SPACIOUSNESS OF THE ORCHESTRAL SOUND

Apart from the analytic way of hearing for controling the tonal nuances and precise balance of the individual orchestral parts, the conductor needs an impression of the total sound of the full orchestra. This includes an imagination of the spaciousness and of the temporal structure of full orchestral onsets as they are to be expected in the audience area. Therefore, the conductor needs a well-balanced ratio of the spatial sound of the hall to the direct sound of the orchestra.

As mentioned before, “spaciousness” of the orchestral sound consists in the impression that - with increasing loudness – the part of the room lying in front of the listeners seems to fill up with sound, often in detail decribed as “apparent source width” and “listeners envelopment”. Only in very reverberant rooms like cathedrals, the sensation of spaciousness can be beyond the front hemisphere and a weak sensation of spatial sound coming from the rear may occur particularly if the main part of the room lies behind the listener [2].

Usually , the conductor stands with his back towards the largest part of the hall; therefore in most halls, he can feel the spatial development of the orchestral sound only up to a very low degree. However, if the hall has sufficient open space in front of him and above him, the conductor can feel a certain impression of the spatial sound development despite the relatively high level of the direct sound coming from the orchestra. Therefore it is not amazing that the spatial conception of concert halls in which the audience surrounds the orchestra like in an arena are well received just by conductors. A typical example for such halls is the Berlin Philharmonic, and from this standpoint it is not surprising that the reflectors above the orchestra in concerts with Herbert von Karajan were always located in their top-most position, i.e. higher than in the optimum position for the sound transmission into the audience area. Under these aspects, it will be interesting in the next future to watch the height of the reflectors above the orchestra in the the new of the Danish Radio Concert Hall in Copenhagen that is just under construction – the interior being more or less a copy of the Berlin Philharmonic.

Furthermore under this point of view, it might be explicable why in an opinion poll among internationally reputated conductors made between 1950 and 1955 just among those concert halls that have been evaluated as being acoustically excellent, there have been several in which the height above the orchestra was much higher than recommended at that time due to the state of the art and even today under aspect of the players' mutual hearing. Obviously, the large height that a room has above the conductor gives him the impression of tonal spaciousness that cannot occur in front of him. In this connection it might be notet that Karajan in the 60's considered the Massey Hall in Toronto, which has a height of about 30 m above the orchestra, as one of the most outstanding halls in the world – at a time when nobody spoke about spaciousness [3].

A particular advantage of the tonal spaciousness felt by the conductor is to be seen in the fact that he can get an impression of the increasing tonal volume as a part of the orchestral dynamics, and he consequently is saved to force the loudness dynamics as well as the sharpness of the tonal attacks too much.

CONCLUSIONS

Summing up these results, the following details for the acoustic situation of a conductor standing in front of an orchestra can be pointed out:

- Horizontal or only less declined sound reflections from the side walls of the podium support the conductors control of the homogeneity of the string groups if the distance between the walls and the players of the back desk is not too large.
- Sound reflections coming from above from a height of about 8 m, support the mutual hearing of the players, but for the conductor, do not improve the evaluation of the homogeneity of the string groups (compared with the direct sound alone).
- Sound reflections coming from above (or from inclined directions) from a height of 12 m and more, can create a certain spatial impression of the orchestral sound for the conductor.
- Reflecting areas above the winds support the conductor's control of the dynamic balance between winds and strings if they are faced in such a way that the reflected sound of the winds is concentrated to the conductor.
- Reflections from the lower part of the rear wall do not make the evaluation of the dynamic balance between winds and strings much easier.
- Rising audience seats and galleries behind and to the side of the orchestra support the spatial impression received by the conductor.

These acoustic demands for the conductor's location certainly do not agree with the acoustic demands for the mutual hearing of the orchestral players in all points. Therefore it is impossible to define "optimum demands" for the acoustic situation on an orchestral podium. Thus, acoustically good concert hall always may differ in that way that they accommodate either more the ideal of the conductors or of the performing musicians.

Finally it should be noted that a decision about the seating arrangement of the orchestra can not be made on the basis of the sound impression at the conductor's location in any hall. Particularly the strings sit in each version of the positioning always facing directly the conductor. Therefore he cannot compare the effect of the directivity of the instruments on the sound to be heard in the audience area if different seating arrangements of the string sections are used [1].

References: [1] J. Meyer: Akustik und musikalische Aufführungspraxis. PPVMEDIEN publishers Bergkirchen, 5th ed. (2004). – Engl. Edidtion to be translated for Springer Publ.
[2] W. Kuhl: Räumlichkeit als Komponente des Raumeindrucks. Acustica **40** (1978) 167-174
[3] F. Winckel: Über den Einfluss der Deckenhöhe auf die Klangqualität von Konzertsälen. Report 4th ICA Congress Kopenhagen (1962) paper M 37