EXTREMES, FLEXIBILITY AND AUTHENTICITY IN ORCHESTRA PIT ACOUSTICS

Author: A James

1. Introduction

Recent discussions with performers, musical directors, orchestra managers and theatre consultants have revealed showed starkly opposing views about the fundamental requirements of orchestra pits. The most controversial question was the extent to which the pit should be covered, with perceived implications for clarity, balance and ensemble, and concerns about increased risks of noise-induced hearing loss. This paper reviews current knowledge on these subjects, almost all of which refers to large-scale 19th and 20th century opera; considers the effect of orchestra pit design on performers and performances; and discusses whether the “modern” (i.e. 19th century) arrangement of instrumentalists in an orchestra pit is applicable to earlier operas.

2. Constraints in Modern Orchestra Pit Design

Acoustics is rarely high on the list of priorities in orchestra pit design. The acoustician has to work within the constraints of other factors which will also contribute to the players’ overall perception of a venue, which includes their appraisal (conscious or sub-conscious) of the acoustic. Some of these are discussed below.

2.1 Height and stage overhang

There is considerable disagreement as to how much (if any) of a pit should extend under the stage. Acousticians and theatre consultants in the UK generally believe that in large-scale opera, brass and percussion should be under the stage to reduce the sound level from these sections - otherwise the orchestra will

simply drown out the singers in tutti sections. This view is supported by Mackenzie's survey of some 5,000 opera-goers [1]. Most respondents to this survey thought that in large-scale works, pit orchestras were generally too loud for the audience to hear the singers properly, even where pits were partially covered. There is a broad consensus among consultants and performers that the maximum depth of overhang should not exceed either 3 m or 40% of the pit area.

All of the professionals consulted stated that the ceiling height in the covered part should not be less than 2.5 m. Relatively few pits in UK touring houses meet this criterion. Mackenzie [1] and Naylor [2,3] found that surprisingly few players thought lower ceiling heights to be either a practical or a psychological problem, and Mackenzie reports that 2.0 m was generally considered adequate. This survey was, however, limited to musicians accustomed to playing in covered pits - players from other countries, accustomed to open pits, may find low ceilings in covered pits claustrophobic.

2.2 Floor area

The typical allowance on an orchestral platform of 1.1 m^2 per player is considered inadequate for orchestra pits. A common recommendation is 1.2 m^2 per player in open pits, increasing to 1.5 m^2 per player under the stage overhang. The specification sought by one well-known touring opera company for a partially covered pit in a new theatre is 109.5 m^2 for an orchestra of 65 players, an average of 1.7 m^2 per player.

The useful floor area of a pit is substantially less than the plan area as locations close to walls and to changes in floor level are frequently unusable. Naylor [3] found that most players consider lack of playing space to be a problem in some or all pits. Many players commented on the need to adopt uncomfortable postures to avoid collision with others while playing. This inevitably affects concentration and hence quality of the performance.

2.3 Seating rake and rostra

On the concert platform, players at the back are raised higher than those at the front, to assist sound projection and sightlines. In covered orchestra pits, players at the back normally have to be lower than those at the front. Seat positions in pits are often precarious, with concerns about seats falling off rostra likely to affect players' concentration. In Naylor's survey, many players commented that "one floor level is best". Where split levels are inevitable, there are obvious safety benefits in having a few large rostra rather than many small ones.

2.4 Sightlines

In open pits, sightlines are seldom more of a problem than on a concert platform. In covered pits, however, Naylor [3] found that only 25% of wind, brass and

percussion players often have an adequate view of the conductor. It is not enough to ensure that all players can see the conductor - it is also important that the angle of view to the conductor should not be much higher than that to the music on the stand.

2.5 Other factors affecting players

Superficially minor annoyances can affect the state of mind of the players before and during a performance, and hence may affect the performance itself. Such factors include poor backstage facilities, poor standards of decor and cleanliness in some pits, difficult access and egress, trailing cables, uncomfortable seats and poor lighting.

3. Acoustic Design

3.1 Acoustic absorption

In pits with acoustically reflective surfaces, players close to walls or under a low ceiling will receive high levels of very early reflected sound. This can lead to very unpleasant and confusing coloration of the sound. Given that in most pits, many players' view of the conductor is impaired, it is important that players should be able to hear each other to achieve good ensemble. As most of the acoustic absorption in the pit will come from the players themselves, it is possible that diffusion rather than absorption will be required on the walls and ceiling. Almost without exception, players prefer acoustically hard floors.

3.2 Orientation of surfaces

The form of the pit is largely constrained by structure. The only practicable changes are normally to angle the side walls and possibly the ceiling to avoid "flutter echoes" between parallel surfaces. With the pit fully occupied, however, flutter echoes are unlikely to occur because the musicians themselves tend to absorb and diffuse this reflected sound. Suitably angled side walls may, however, direct reflected sound towards the auditorium [11]. Acoustic modelling and measurements are required to determine whether reflectors over the orchestra pit can have any significant effect.

3.3 Pit rail

Replacing the traditional pit rail and curtain with a low reflective screen can improve ensemble between orchestra and stage at the expense of some loss of sound to the audience, particularly at high frequencies. At the Bayreuth Festspielhaus this is carried to the extreme with an almost completely enclosed pit, conceived by Wagner to give the orchestra a uniquely dark, mysterious sound. The Festspielhaus is dedicated entirely to Wagner operas, and this

acoustic would not be considered suitable for the more general repertoire. At Glyndebourne the pit rail may be either reflective or transparent, and it is reported that music staff prefer the transparent option. [4]

4. Noise at Work and the Risk of Hearing Damage

Note - All of the following applies only to large-scale nineteenth and twentieth century opera and ballet. Sound levels during smaller-scale and earlier works are generally much lower.

4.1 Subjective reactions

A major and recurrent concern among players in orchestra pits is hearing damage due to the high sound levels that they experience. 75% of respondents to Naylor's survey stated that in partially covered pits they are exposed to excessive loudness, mostly from brass and percussion. 27% of players stated that they can not hear themselves at all during loud tutti passages, and 26% said that they sometimes became so confused by the loudness of the noise that they were unable to play. Only 4% stated that they wear earplugs (one type of earplug is recommended by the Musicians' Union). 13% reported occasional physical pain during very loud passages, and "ringing ears" or temporary threshold shift after performances. 6% believed that they had suffered permanent hearing damage, but none reported having or requesting audiology tests to confirm this.

4.2 Measurements and risk of damage to hearing

Kahn [5] measured sound levels and personal noise dose exposures (LEP,d) for a viola player and for a trumpet player sitting directly behind him during a three-hour opera, in a partially enclosed pit containing an 80-piece orchestra. Most players perceive that the highest noise levels are caused by brass and percussion, and that the players directly in front of these sections are most at risk of hearing damage. The measurements, however, showed the following:

- Averaged over a performance, the trumpeter was exposed to higher levels of noise than was the viola player. The level at the viola player's left ear was substantially higher than at his right ear. These findings suggest that most of these players' exposure is to noise from their own instruments, rather than to instruments around or behind them.

- Most musicians are in the near field of their own instruments, which is relatively unaffected by their surrounding. If, as the above suggests, musicians' noise exposure is dominated by the sound from their own instruments, the risk of hearing damage in partially enclosed pits is not substantially greater than to musicians in open pits or on the concert

platform, certainly over a relatively small number of performances.

- Highest sound levels during loud passages are dominated by brass and percussion sections, which typically play for a much smaller proportion of the performance than do the strings and woodwind. Hearing damage is, however, believed to be a function of the average sound levels experienced over many performances, not to instantaneous levels. Hence players may be right to believe that brass and percussion cause the highest levels of noise, but wrong to believe that this causes hearing damage.

The Medical Research Council stated in 1985 (on what evidence is not recorded) that there is a "slight but material" risk of hearing damage to classical musicians over the duration of a career. Naylor's measurements [2] in various covered and uncovered pits gave levels in the range 86 to 92 dB LAeq averaged over complete acts, with peaks from 105 to 110 dB(A). For musicians playing at these levels for more than about 10 hours per week, many players' hearing exposure is likely to exceed the first action level of the Noise at Work Act. This is generally confirmed by further recent measurements by Kahn [6] which show that during intensive periods of playing (8 performances of a 3-hour opera or ballet per week) many players' hearing exposure will exceed the second action level of the Noise at Work Act.

Susceptibility to hearing damage varies from person to person. Musicians may not form a typical population in this respect, because from childhood many have exposed themselves to surprisingly high levels of noise during instrumental practice. Furthermore, the action levels in the Noise at Work Act were based on research using industrial noise, and it is not clear that the same levels represent the risk of hearing damage for other types of sound. A substantial and widespread programme of measurements combined with audiometric tests would be required to reach firm conclusions on the relative risk to musicians.

4.3 Baffles and screens

Experiments have been made with free-standing screens and baffles in orchestra pits to absorb or diffuse sound. These are used by some opera companies, reportedly with some success. Reflective baffles are unlikely to reduce overall sound levels unless they are designed to reflect the sound into an absorptive surface - preferably the ceiling. To do this they would have to be relatively large in area, and would take up more space than is available in most pits.

5. Loudness and Balance

5.1 Loudness of orchestra

It is important to consider that the acoustic efficiency of modern woodwind, brass and percussion instruments is substantially higher that even 50 years ago. There are no published measurements, but typically a modern wide-bore trombone or clarinet might be 5-10 dB louder than the narrow-bore equivalent used in the 19th century. These developments were matched by increases in the size of auditoria. It follows that performances of eighteenth-century opera using period instruments are not realistic in large nineteenth-century opera houses. A recent example was a production of Mozart's Magic Flute using period instruments at the Royal Opera House, Covent Garden. This work includes many passages of ceremonial music for brass and woodwind, and the reproduction 18th century trombones in particular were judged incapable of providing the sonority (for which acousticians may read loudness) required in an opera house almost twice the size of that for which Mozart selected his orchestra.

5.2 Balance and ensemble with singers

There is no reason to believe that equivalent increases in the sound emitted by singers have taken place over the same period, and indeed it is difficult to see how they could have done so. Performances of romantic, classical or baroque opera on 20th century instruments probably experience balance problems both within the orchestra, and between orchestra and singers, that would not originally have occurred. Conductors can only adjust for this if they know what balance the composer originally intended. Performances of nineteenth-century music on original instruments should assist in this respect.

Significantly, only 17% of respondents to Naylor's survey [3] felt that in partially covered pits they could generally hear the singers as loudly as they need to for good ensemble. However well both singer and player follow the conductor, there is no substitute for being able to hear each other. Experiments have been tried using electroacoustic feedback from the stage to the pit in the Theatre Royal, Glasgow, and in the Kings Theatre, Edinburgh, enjoyed limited success in improving ensemble in quiet passages [1,2], but not in very loud passages. Compression of the signal would probably help.

6. Performance of Early Opera

The first works generally recognised as operas were performed around the year 1600 in the state rooms of private Palazzi in Florence. These probably accommodated an audience of about 200. The handful of instrumentalists required were on stage, as they probably were in the first performances of Claudio Monteverdi's L'Orfeo, although with a much larger cast and some 40

instrumentalists this must have been conditions rather cramped. As performances in public theatres became more common, the musicians were relocated in front of the stage. A contemporary drawing of the Theatre in Vienna built by Burnacini for Cesti's Il Pomo d'Oro in 1667 shows the instrumentalists at stage floor level, in a narrow space between the stage front and a solid rail, ald a large empty space between this and the front row of the stalls seats [7]. This seems to have been a common arrangement until well into the 18th century; contemporary engravings show operas by Gluck and Haydn performed with musicians at stalls floor level in front of the stage.

The Queen's (later King's) Theatre in London's Haymarket, for which many of Handel's operas were written, had a substantial open orchestra pit in front of the stage. [8] To show off the technique of his singers Handel wrote very ornate arias, often accompanied by fast-moving obbligato parts for individual instruments. These require a degree of contact between singer and player that is impossible to achieve in the modern layout of the pit orchestra, where none of the players can see the stage. There is evidence that the baroque pit orchestra had a completely different seating arrangement, with all players facing towards the centre of the pit. This would make sense as the performance would be directed from the keyboard at the centre of the pit, and the first violins, woodwind and perhaps brass players would facing towards the stage where they could see (and hear) the singers. The orientation of the instruments in an open pit is relatively unimportant. At least one recent performance has adopted this seating arrangement with great success [9].

It should be remembered that many of the instruments of the time were very much quieter than their modern counterparts, with the widespread use of theorbos and other long-necked lutes which would probably be barely audible if placed in a sunken pit. Much of the singing would be performed from forestages that have now largely vanished [10] and the auditoria were relatively small. A simple calculation shows that when these early operas are produced in large opera houses, with instruments muffled by a deep pit and singers behind a proscenium, two effects are likely - the music will not be loud enough and the balance between singers and instruments will suffer.

Ironically, the performances of early opera most likely to approach the composers' intentions are those in spaces not designed for opera, forcing the producers to think about the size and locations of their forces, rather than accepting by default the layouts of opera houses which were designed for a totally different type of opera. In this respect many of the most successful productions in London have been those by touring companies such as Opera Factory and English Touring Opera in the unlikely setting of the Queen Elizabeth Hall. The QEH has no pit so that the instrumentalists normally sit at the sides of the stage where, to the obvious benefit of ensemble and balance, they can see and hear the singers.

In conclusion, it seems that for a substantial part of the opera repertoire, the orchestra pit and layout developed for nineteenth-century opera is wrong acoustically as well as historically. In the design and refurbishment of auditoria houses the theatre designer and acoustician should allow for different types of opera as they do for different types of theatre; with the widespread use of lifts to form forestages and orchestra pits at different heights, many of the means to achieve this already exist. Better communication between acousticians, musicologists and musical directors would help to give musically satisfactory performances of early operas even where for practical reasons these have to be in acoustically unsuitable venues.

7. References

[1] R.K Mackenzie, Heriot-Watt University (1985). The acoustic design of partially enclosed orchestra pits. Proc IoA conference on reproduced sound, pp237-243.
[2] G Naylor, Heriot-Watt University (1985). Problems and priorities in orchestra pit design. Proc IoA, Vol 7, Part 1, pp 65-71.
[3] G Naylor (unpublished). Meeting the needs of the musician in orchestra pit design.
[4] R Harris, “Acoustic design of the Glyndebourne Opera House”, Proc IoA Vol17 Part 1 (1995).
[5] S W Kahn, London (1994). What is an acoustically correct performance? Music and the Noise at Work regulations. Proc IoA, Vol 16, Part 2 pp 313-318.
[6] Private communications with Simon Kahn, March - April 1997.
[7] D Harman and A Milner, “Late Renaissance and Baroque Music”, Pub Barrie & Jenkins 1988, Plate XXVI
[8] “Handel” Christopher Hogwood, Pub. Thames & Hudson (1984).
[9] Private communication with Professor Jakob Lindberg, April 1997.
[10] I Mackintosh, “The theatrical and acoustic significance of the forestage in opera house design ...”, Proc IoA Vol 14 Part 2 (1992)
[11] J O’Keefe, Toronto (1995). Acoustic conditions in orchestra pits and proscenium arch theatres. Proc IoA, Vol 17 Part 1 (1995)
PITS_PRE.DOC

The author is grateful to Karen Williams for musicological research, to Simon Kahn for suggestions and material on noise assessments, to Jakob Lindberg for helpful discussion and references, and to Graham Naylor for supplying an unpublished reference.