

The Concert Venue

Thoughts on Acoustics for Choirs

by Walter Marzilli

Introduction

Physical-acoustic implications concerning the broadcasting of sound are many and extremely complicated, and this is not the place to discuss absorption coefficients, acoustic impedance, and so forth. It would be more useful, in this context, to turn our attention to distinguishing between two separate occasions: when the choir sings during a church service, and when it sings in a concert. The consequences can be very far-reaching when, in the first instance, the sound vibration is not conveying just any sound, but *the Word of God*. When faced with such a serious matter, each of us must do our best not to disturb this transmission, since the Word of God must go straight to the hearts of those listening, not just to the ears. When we look at the matter in these terms, we can see how any reflection on it would soon touch the boundaries of theology, ethics, philosophy, and more; so it is imperative that we pause here and look for some solid ground. Let us confine ourselves to a few essential reflections which will deal marginally with the presence of the choir in the liturgy, but most of all will deal with the more frequent occasion, the concert.

The Choir's Place

Until the sixteenth century the choir was always positioned with its back to the congregation, facing the altar. Figure 1

shows a choir in a print dating from 1580.[1] The opening of the San Cassiano theatre in Venice in 1637 – the first theatre to be opened to the public – marked the completion of a process of rotation of the choir: first the choir turned to face the congregation, then it expanded to become two, three, or six choirs, or more, in order to surround the audience completely. Because by this time the audience, historically and socially, had reached a position of such importance that it could no longer be underestimated.



The liturgical reform introduced by the Second Vatican Council (1962-1965) definitively moved the altar much further forward, closer to the congregation, although this was not a general obligation. This brought about a significant alteration of the original acoustic design of any and every church. It should be remembered that the positioning of the officiating priest in the apse had a highly refined acoustic significance, because from here his voice would expand in sound waves projected directly towards the people, even when the celebrant turned *versus Orientem*. [2] The phenomenon illustrated in fig. 2 is caused by the acoustic law governing the reflection of sound

waves, which “bounce” off a wall at an angle of reflection equal to the angle of incidence.[3] If the wall is concave the result is that shown in fig. 2.



On the stage of a theatre, the area of corresponding acoustic significance to the celebrant's place in church is known as “the Callas spot”. This place is much sought-after by opera singers because it is from here that the voice is best heard. An inverse approach would be to position microphones in the celebrant's place in order to record a vast mass of sound on the strength of the parabolic reflection of the sound waves from the concave wall.[4] This is exactly what Sergiu Celibidache's sound engineer used to do, and so did the Pink Floyd's engineer, both of whom were noted for always seeking a concave place in front of which they could position their microphones for live recordings ... this explains the need for the famous *acoustical shell* placed behind musicians when they perform out of doors – a word about this later – or indoors in a place with little reverb. The architects of the ancient world solved this problem at source by designing the apse.

This said, it follows that to optimise its acoustic power, the

choir should be positioned in the apse: the very place where, in all historic churches, we find the wooden choir stalls. The sound made by the choir needs to be completely formed before it is finally diffused. The position of the conductor, actually within the choir, is the least pleasant, since he or she hears the sound of the choir before the vital contribution made by the acoustic surroundings has completed the sound. You would not go to the baker to buy, separately, flour, water, yeast, and salt; when you go to the baker's you expect to come away with the finished product – bread – and the same should apply to the sound of the choir.[5] To reach fullness of sound, the choir requires two essential ingredients: space and resonance. The first is not obtained by placing the choir too near its audience; and the second requires a curve encircling the singers, or at least a wall behind them. Both these conditions can be immediately fulfilled by placing the choir in the apse. After all, during the liturgy, the choir has never sung in a direct, but always a transversal way: being, not seeming.[6]

Concerts, though, are different: here the visual aspect too is important, and at a concert, listening becomes the most important factor, whereas in the liturgy it is only a part of the whole. For this reason – and also so as not to compromise the sound of a small choir or a group of singers with limited ability to project sound – it is advisable to position the choir in front of the altar, while maintaining the necessary distance from the audience. The best arrangement is for the choir to form a semicircle. What is lost in the directional quality of sound in a semicircle as opposed to a straight line, is offset by the way in which the sound will be immediately more assured and more closely-woven. Singers who stand in a close semicircle can keep better contact with one another.

The Dome

Don't forget about the dome. It creates a rising air vortex which draws sound upwards, aided by the heat generated by the lighting directed on to the choir. Placing the choir right under the dome means sending upwards, and consequently losing, a considerable quantity of sound. However, this only really applies to very high domes. Usually – fortunately – it is only the perspective effect of the frescos which makes the dome seem so high, so close to Heaven ...[7] The same thing happens behind the proscenium in the theatre.

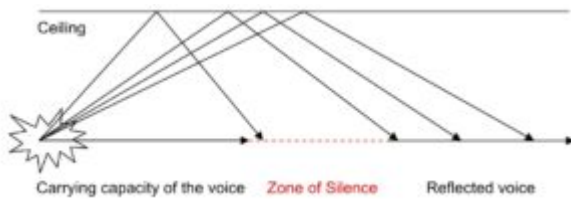
The Choir Loft

Sometimes the raised choir loft was part of the original architectural design and has its own acoustic function. In this case, it is advisable to make use of it, because from the height of this gallery the sound of the choir can extend freely to fill all the available space, untrammelled by all those obstacles which inevitably impede its propagation when the source of the sound is positioned on the floor.[8] It is an excellent spot in which to place a second choir, or to begin a concert, enveloping the audience with ethereal sound; and the concert could then continue with the choir singing as they enter the church in procession.

The Amplification of Sound

In very large churches, one may be strongly tempted to amplify the choir, but the microphones capture the sound and send it instantly a considerable distance away, before the live sound can reach there. The sounds therefore are superimposed on one another, increasing reverberation and making words and harmony more difficult to understand. It is advisable to place loudspeakers only where the sound does not reach, but this is a very rare occurrence, only found in the presence of a particular architectural space called the *zone of silence*,

illustrated in fig. 3:



It can be seen from fig. 3 that there are three distinct acoustic zones in a defined enclosed space: one space where the direct carrying capacity of the voice gives a fine, solid sound; the *zone of silence* (not always present) where the voice does not reach directly, but only through a very few reflected sound waves (those of the low notes, more spherical than the others), giving a delicate but not very satisfactory sound;[9] and the reflected sound zone, giving a soft sound like the preceding one, but less ethereal and more present.[10]

Reverb

Another parameter to be taken into account is reverb. The optimum figure for a choral performance is estimated to be at least two seconds.[11] This enables the singers to have ideal control of their voices and gives the audience a clear yet well-blended sound to listen to.[12] A fair amount over this figure and the singers will have a very rewarding proprioceptive sense of their voices, while the audience will be condemned to a very demanding and confused listening.[13] Below two seconds, on the contrary, the audience will easily be able to hear every smallest nuance, while the singers will have a horrible sensation of total vocal isolation, making it difficult to keep control of emission.[14]

The absence of any reverb can be countered in various ways. The first is to remove any sound-absorbing materials such as carpets, curtains, etc. Then the singers should stand in a close, tight semicircle, so that each can be aware of the others' voices and their voices are not projected towards the audience without any control, as can happen when the singers stand in a straight line or a wide semicircle. Another effective way to increase the control each singer has over his or her voice is for the singers to stand further apart from one another: in this way the singers hear their own voices before those of the others. Or again, singers can alternate (STSTSTSTST-ABABABABAB) so that each voice is enclosed between two different voices. Obviously, the two latter solutions need to be tried out and practised during rehearsal. Both these solutions cause few problems at the outset and offer many advantages in terms of enhancing each single voice, improving the fusion of voices, characterising timbre, encouraging the evolution of colour, etc., but these cannot be dealt with in depth here. An excess of reverb can be contrasted by applying the opposite techniques: putting down carpets, opening closed curtains, and standing choristers in a straight line to increase directivity of sound.

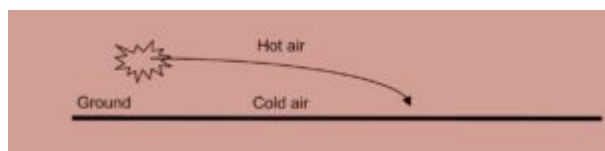
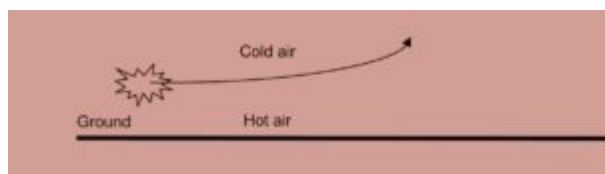
The Haas Effect

This is the name given to a particular acoustic phenomenon: a listener who moves just thirty centimetres from the symmetrical centre between a pair of stereo microphones, will hear only the microphone closer to them, and not the other. If we think of the choir as an enlarged stereophonic source (usually with the high voices on the left and the deep voices on the right) we can reasonably suppose that listening from a position non-symmetrical in relation to the choir – which in practice means any bench in any church, separated as they are by the central corridor – would produce the same effect, so that the sections further away are not heard. Fortunately, the

presence of reverb mitigates this negative effect, which would otherwise make it impossible to listen to any music. But this is the reason why the microphones are always positioned in the centre of the corridor and never to one side. Could this, and not social considerations of caste[15], be the true, primitive-empirical reason why important people are always seated at the centre of two sets of benches?

Singing Out of Doors

This is the least favourable situation, since there is no enclosing architectural space which – as we have seen – has a fundamental part to play in the formation of the final sound. Moreover, another phenomenon – a particular type of refraction[16] – causes further problems. The sound waves are dispersed upwards when the ground is warmer than the air (fig. 4), while the range of the sound is much reduced when the ground is colder than the air, since in this case sound tends to sink downwards (fig. 5).



In both cases the situation causes negative effects which must be avoided. It is essential to overcome the problem by using microphones and loudspeakers to create a virtual enclosed space. However, there is a price to pay for this: the timbre

will inevitably be lost, since as well as the alterations made by the mixer – which may produce improvements – it should be remembered that every microphone has its own particular sound ... Without taking into account the loudspeakers, each of which has its own “voice”. Also, the singers will be quite unable to hear each other and will need to have recourse to a monitor and/or the acoustical shell referred to at the beginning. In any case it is essential to be flexible and to have sufficient familiarity and confidence with outdoor spaces, microphones, monitors, the dispersal of sound, and so forth.

[1] Filippo Galle (1537-1612): *Cappella Musicale*. Detail of an engraving from: J. Stradanus, *Encomium Musicae*, Antwerp, 1580 ca.

[2] The widespread theory that the celebrant said Mass “with his back to the congregation, ignoring them” is not correct: on the contrary, the celebrant was leading the people in an ideal procession towards the east, that is to say, towards God, and this was carried out with loving care, acoustically speaking – as can be seen from fig. 2. The objections usually raised against Mass celebrated towards the east/God are based on the observation that the Pope in St Peter’s basilica celebrates Mass facing the people: but this does not take into account that the altar in St Peter’s faces east. This is partly owing to the positioning of the altar above the tomb of St Peter, and partly to the geological configuration of the hill which rises behind it. In this, it differs from the majority of ancient churches, around which urban centres subsequently grew.

[3] We should take into account that computer graphics are unable to make the angle of incidence and the angle of reflection perfectly symmetrical.

[4] This is the same principle as that governing parabolic television antennae.

[5] This is why placing microphones too close to the choir spoils and thwarts all the efforts made by conductor and singers alike to create an appreciable fusion of the voices. The microphones pick up the single voices separately and are unable to capture the overall acoustic effect, which includes the contribution made by the reflection of sound within the architectural surroundings.

[6] Bear in mind, however, that post-conciliar Church legislation invited the singers to move out of the apse and mingle with the congregation, of which they are a part. Without disowning the *munus* of the choir's ministry, if possible...

[7] We may interpret this striving towards Heaven, towards the Creator, as a symbol of the power of one church relative to another, at a time when the Church was also a notable temporal power.

[8] The elevated choir loft is motivated by considerations superior to simple acoustics. When you enter any historic church of some height, it is never possible to see at the same time the floor below the altar and the ceiling above it. This symbolises the unbridgeable gap between humankind and God which was the basis of pre-conciliar theology. There was, however, one chosen spot from which one could look at the apse and see, at the same time, both the floor (humankind) and the ceiling (God): the raised choir loft.

[9] This refers to the notorious area where someone who was sitting there during the concert will unfailingly say, «This evening you all sang a bit too quietly ...». Never put the microphones here when you are recording; not even the second microphone for atmosphere.

[10] Bear in mind that the reflections do not come only from

the ceiling, but also from the side walls, the floor, the pillars, the people present, etc.

[11] Note that this is the time required by a sound in order to decrease its maximum power by 60 decibels (one million times). In practice, the time considered is the time from the end of the sound to its decreasing to zero.

[12] Bear in mind that any reflected sound is superimposed on the direct sound during the first one-tenth of a second of listening, thus reinforcing the original sound.

[13] The conductor will need to broaden tempo and rests to avoid superimposing notes and chords.

[14] In this case the conductor would be well advised to slow the tempo of the music, which might otherwise sound hollow and stark.

[15] There are many acoustic situations which musicians of the past solved empirically, without having the necessary knowledge. But this would be an interesting theme to develop at some future time....

[16] We refer to refraction when the sound wave crosses two spaces of differing temperatures.

Translated from the Italian by Gillian Forlivesi Heywood, Italy