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*I*

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*Theme and Variations*



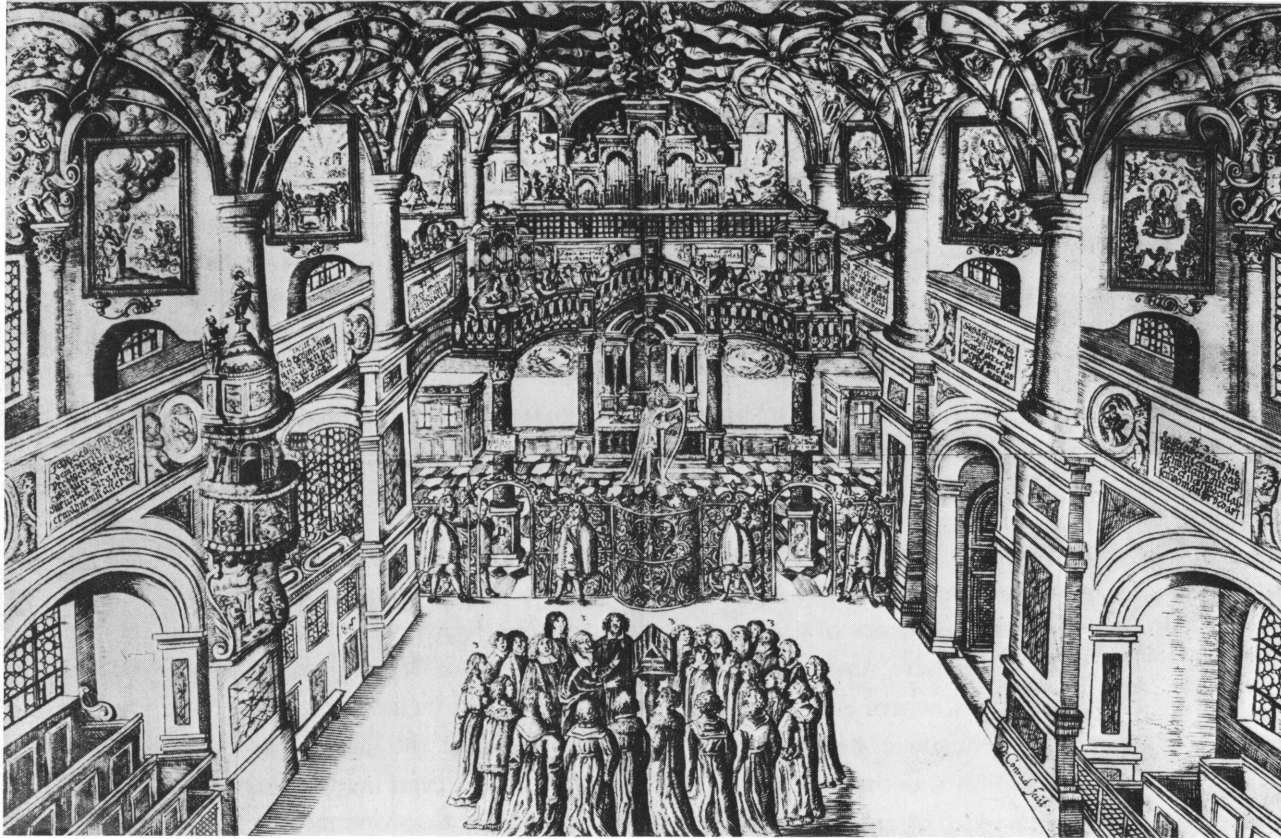
The English acoustician Hope Bagenal used to say that all auditoria fall into two groups: those with the acoustics of the cave and those with the acoustics of the open air. From the former, where music originated, grew the concert hall, and from the latter, where the spoken voice belongs, grew the theater.

Wallace Clement Sabine, the pioneering American physicist (in his paper “Melody and the Origin of the Musical Scale,” delivered in Chicago in 1907), argued that room acoustics have such an influence on musical composition and performance that the architectural traditions of different races, and hence the acoustic characteristics of their buildings, influenced fundamentally the type of music that they developed. Whether the music of a region developed as predominantly melodic or rhythmic depends on whether the race of people were historically “housed or unhoused, dwelling in reed huts or in tents, in houses of wood or stone, in houses and temples high vaulted or low roofed, of heavy furnishings or light.”<sup>1</sup>

The urge to sing in the shower or to whoop in a tunnel, the ability of even unmusical people to sing in tune in a reverberant space—these suggest a relationship between music and the acoustics of a hard-surfaced enclosure. From early times the acoustics of stone buildings have surely influenced the development of Western music, as in Romanesque churches, where the successive notes of plainchant melody reverberate and linger in the lofty enclosure, becoming superimposed to produce the idea of harmony. Western musical tradition was thus not only *melodic* but *harmonic*, even before the notion grew, around A.D. 1000, of enriching the sound by singing more than one melody at once and producing the harmony at source.

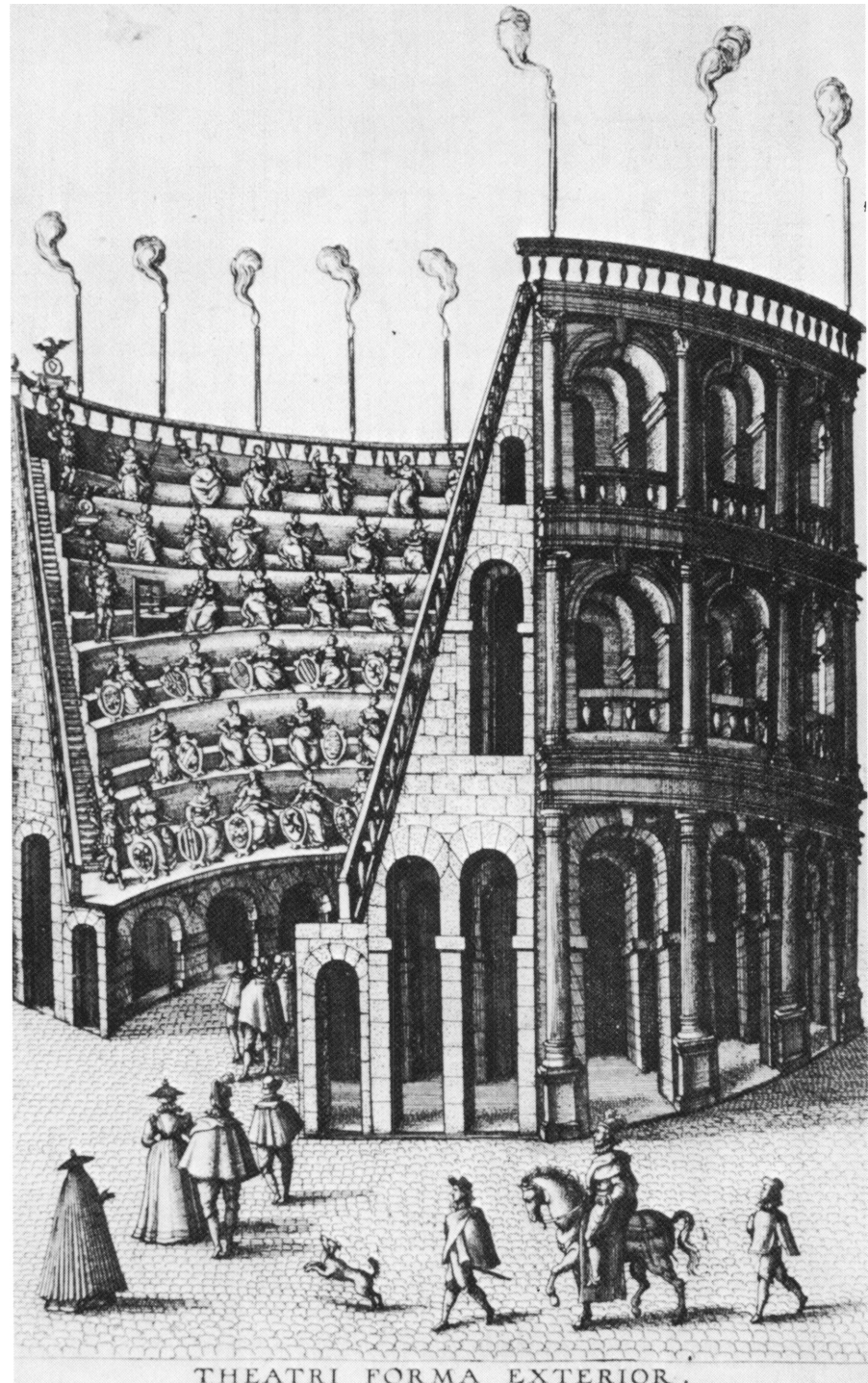
In the Middle Ages a close relationship that was not only acoustic developed between music and the Gothic cathedral, for both were expressions of the medieval concept of cosmic order. Philosophers theorized that the entire universe is ordered according to whole-number Pythagorean ratios, or musical consonances, and it was in recognition of this theory that the performance of music had particular significance in the medieval church. When Abbot Suger began in 1129 to rebuild his abbey church of St. Denis near Paris, which was to become a seminal building to the Middle Ages, the building itself was proportioned according to these same consonances, in order that the church would stand as a microcosm of the universe; the more so, one might say, as the building gave acoustic harmony to liturgical plainsong melody through its own reverberation. As Otto von Simson has said, architecture was the mirror of eternal harmony, while music was its echo.<sup>2</sup>

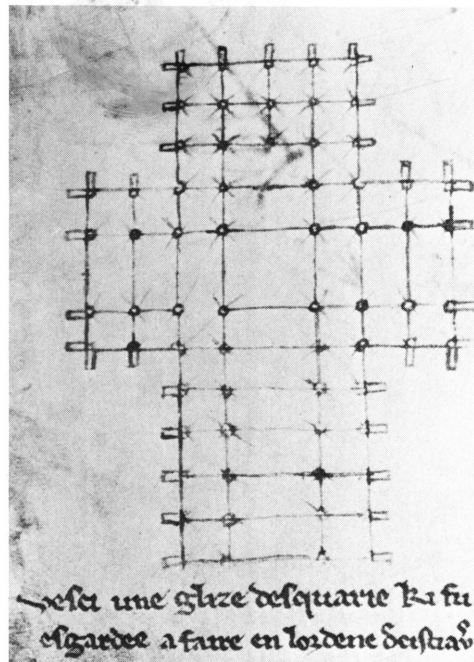
Auditoria with the acoustics of the open air, on the other hand, like the classical amphitheater, have traditionally lent themselves to events where the intelligibility of speech is



1.1  
Heinrich Schütz in the Palace  
Chapel, Dresden, which has the  
acoustics of the cave. He com-  
posed specifically for this build-  
ing with its long reverberation  
time. (Courtesy Institut für  
Denkmalpflege, Arbeitsstelle  
Dresden)

I.2  
Buildings with the acoustics of the open air derive from the classical amphitheater: *Theatri forma exterior* from *Descriptio publicae gratulationis, spectaculorum et ludorum . . .* by Johannes Bochius, 1595. Engraving by Pieter van der Borcht IV (1545–1608). Portrays the Theater of Peace, a temporary structure built for the entry of Archduke Ernst of Austria into Antwerp.



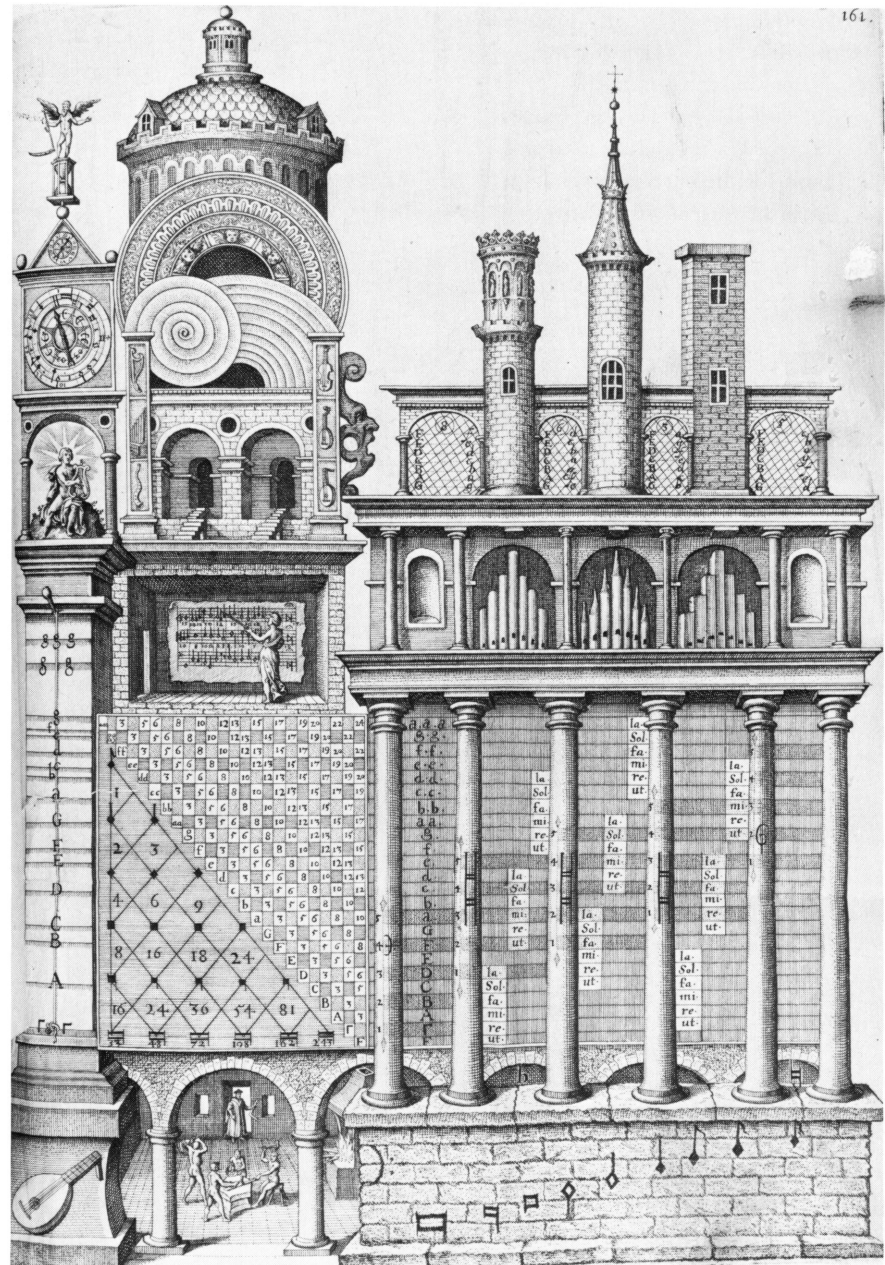


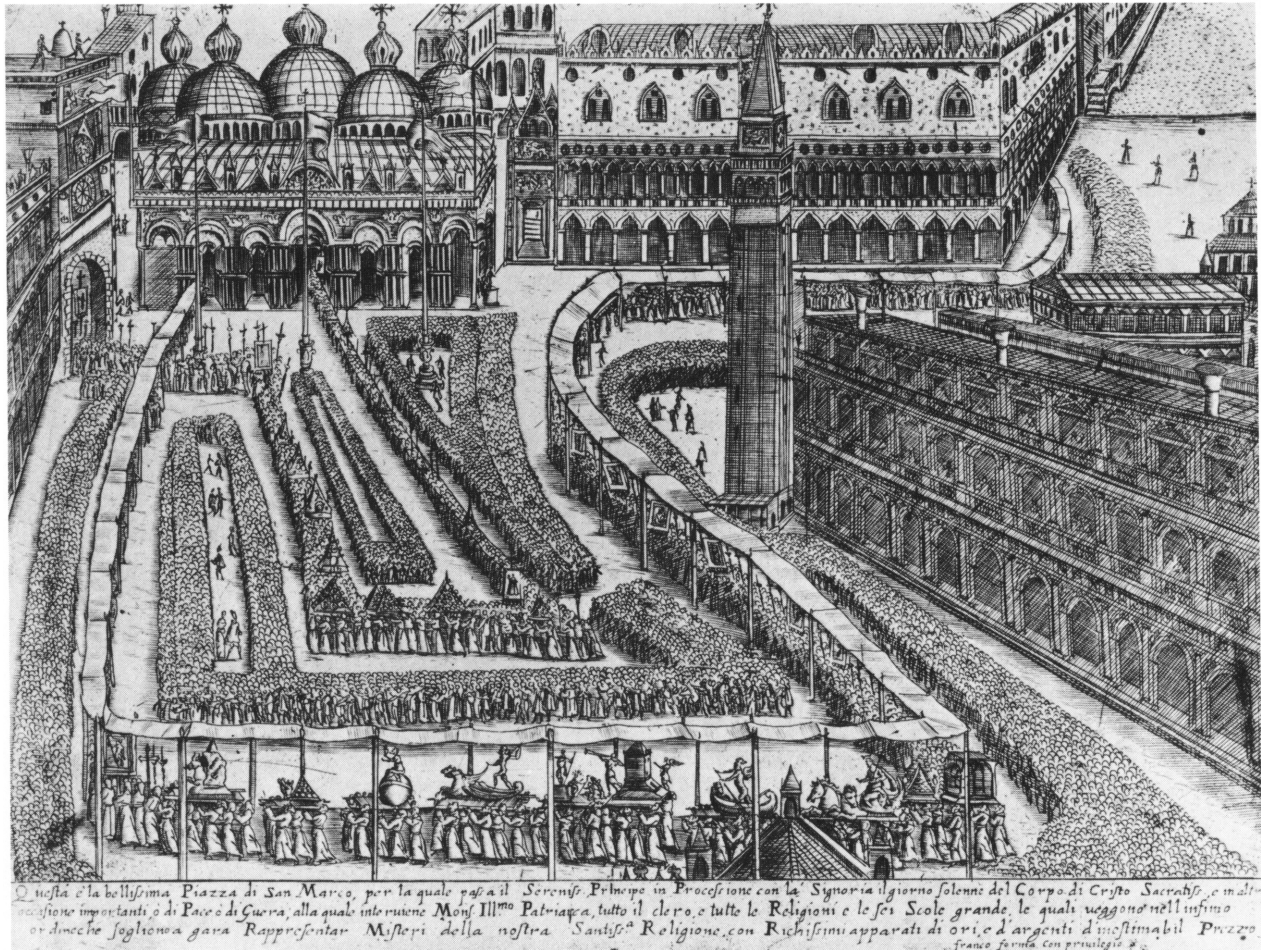
## I.3

Sketch from the thirteenth-century notebook of Villard de Honnecourt showing a design for a church. In the Middle Ages it was thought that the cosmos is ordered by the harmony of Pythagorean numbers—musical consonances being one clear example. The Gothic cathedrals were designed according to the ratios of musical consonances, in order to stand as a microcosm of the universe. (Bibliothèque Nationale, Paris)

## I.4

The Temple of Music, from Robert Fludd's *Utriusque Cosmi Historia*, I, II (1618), p. 161, an imaginary edifice designed around musical symbolism. (British Library)





1.5  
St. Mark's, Venice. From *Habiti d'Huomini*, Venice, 1609: the theatricality of religious festivals was enhanced by their architectural setting. (*Early Music*)

important, whether spoken or sung; that is, where clarity is necessary as opposed to fullness of tone. This is because the open air is sound-absorbing; consequently, the direct sound from a performer—perhaps reinforced by early-reflected sound from a wall around the stage—is not masked by reverberation, as it is in a hard-surfaced enclosure like a cathedral, a cavern, or a bathroom, where sound reflects off the enclosing surfaces for an appreciable period before being gradually absorbed. (The distinctness also depends on the listener being sufficiently close to the performer for the sound energy not to have diminished too greatly with distance.)

When the classical amphitheater became roofed in, as at Palladio's Teatro Olimpico at Vicenza (1580–1583), the baroque, horseshoe-shaped theater developed: the arcs of raked seating were elongated into a U, as at Aleotti's Teatro Farnese, Parma, and evolved into walls of boxes, as at the Teatro SS. Giovanni e Paolo, Venice, which Carlo Fontana remodeled for opera in 1654. Filled with sound-absorptive, elaborately costumed spectators and heavy drapery, and with a low cubic volume relative to the audience size (with a consequently short reverberation time, tending toward “open air” conditions), the Italian opera house had characteristically clear, intimate acoustics, which allowed the rich ornamentation of baroque arias to be revealed to splendid effect.

Both generic types of auditoria—theaters with the acoustics of the open air and concert halls with the acoustics of the cave—have branched into many variations. For example, besides theaters of the Italian baroque type (these are still being built—for instance, the Metropolitan Opera House, New York, completed in 1966), the Wagnerian theaters—including the Festspielhaus, Bayreuth, and the pre-First World War theaters of Max Littmann—were designed to be comparatively reverberant to blend the expressive tonal colors in Wagner's operas. Concert halls meanwhile evolved from the acoustically intimate music rooms of the eighteenth century, such as the Altes Gewandhaus, Leipzig (where the members of the small audience faced each other across a central aisle), to the boomy halls of the later nineteenth century like the Concertgebouw, Amsterdam, and the vast and less than satisfactory pre-Second World War American auditoria based on the analogy of the open-air music pavilions, including the Hollywood Bowl, that were being built at the time.

Composers from Gabrieli to Stockhausen have always taken into account the acoustics of the type of building for which they were writing. As Thurston Dart said in his book *The Interpretation of Music*,

Even a superficial study shows that early composers were very aware of the effect on their music of the surroundings in which it was to be performed, and that they deliberately shaped their music accordingly.

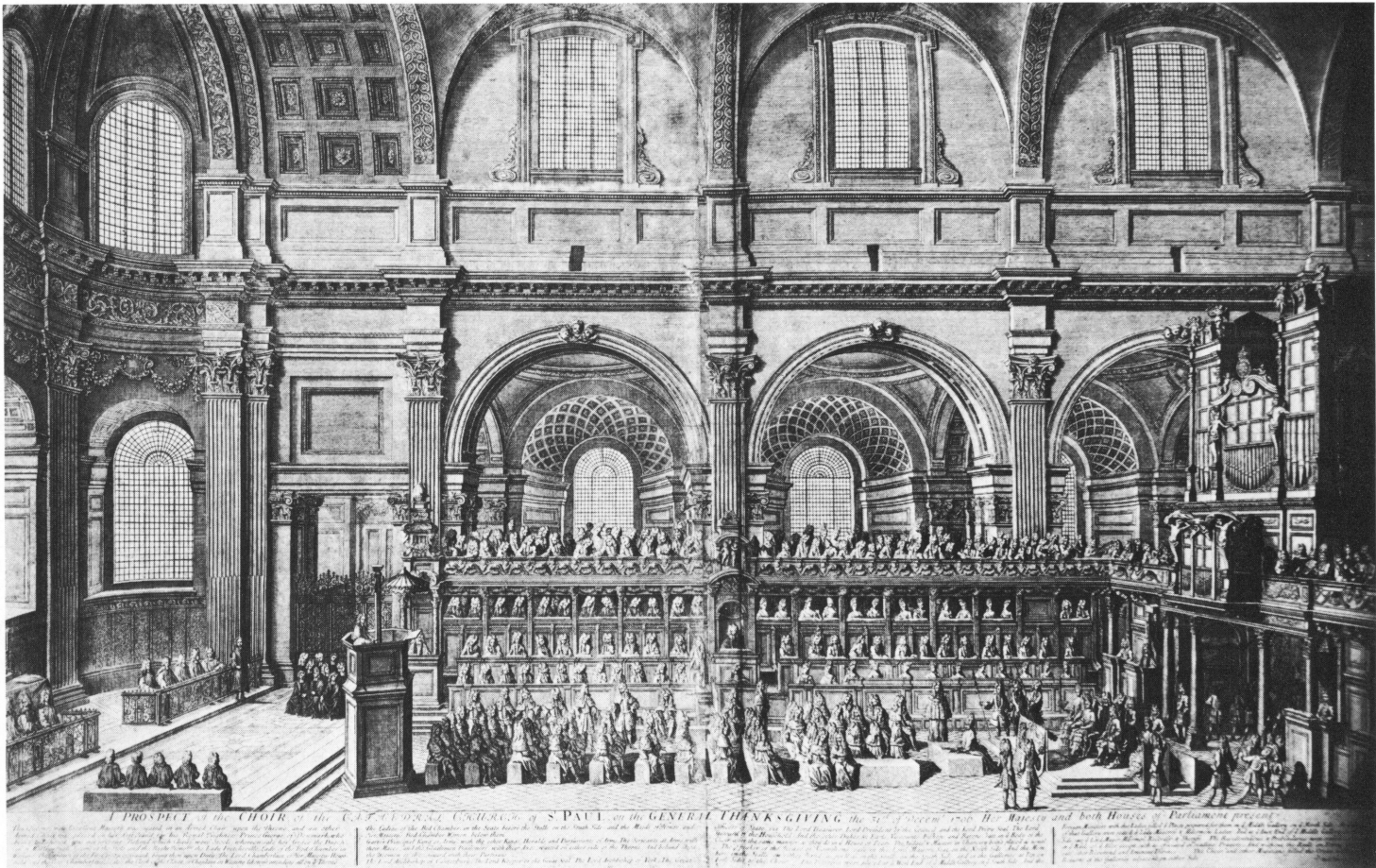


Musical acoustics may be roughly divided into “resonant,” “room,” and “outdoor.” Plainsong is resonant music; so is the harmonic style of Léonin . . . and Pérotin. . . Pérotin’s music, in fact, is perfectly adapted to the acoustics of the highly resonant cathedral (Notre Dame, Paris) for which it was written. The intricate sophisticated rhythms and harmonies of the fourteenth-century *ars nova* . . . are room-music; pieces written in the broader style of the fifteenth century . . . are resonant music. Gabrieli’s music for brass consort is resonant, written for the Cathedral of St. Mark’s; music for brass consort by Hassler or Matthew Locke is open-air music, using quite a different style from the same composers’ music for stringed instruments, designed to be played indoors. Purcell distinguished in style between the music he wrote for Westminster Abbey and the music he wrote for the Chapel Royal; both styles differ from that of his theatre music, written for performance in completely “dead” surroundings. The forms used by Mozart and Haydn in their chamber and orchestral music are identical; but the details of style (counterpoint, ornamentation, rhythm, the layout of chords and the rate at which harmonies change) will vary according to whether they are writing room-music, concert music or street music.<sup>3</sup>

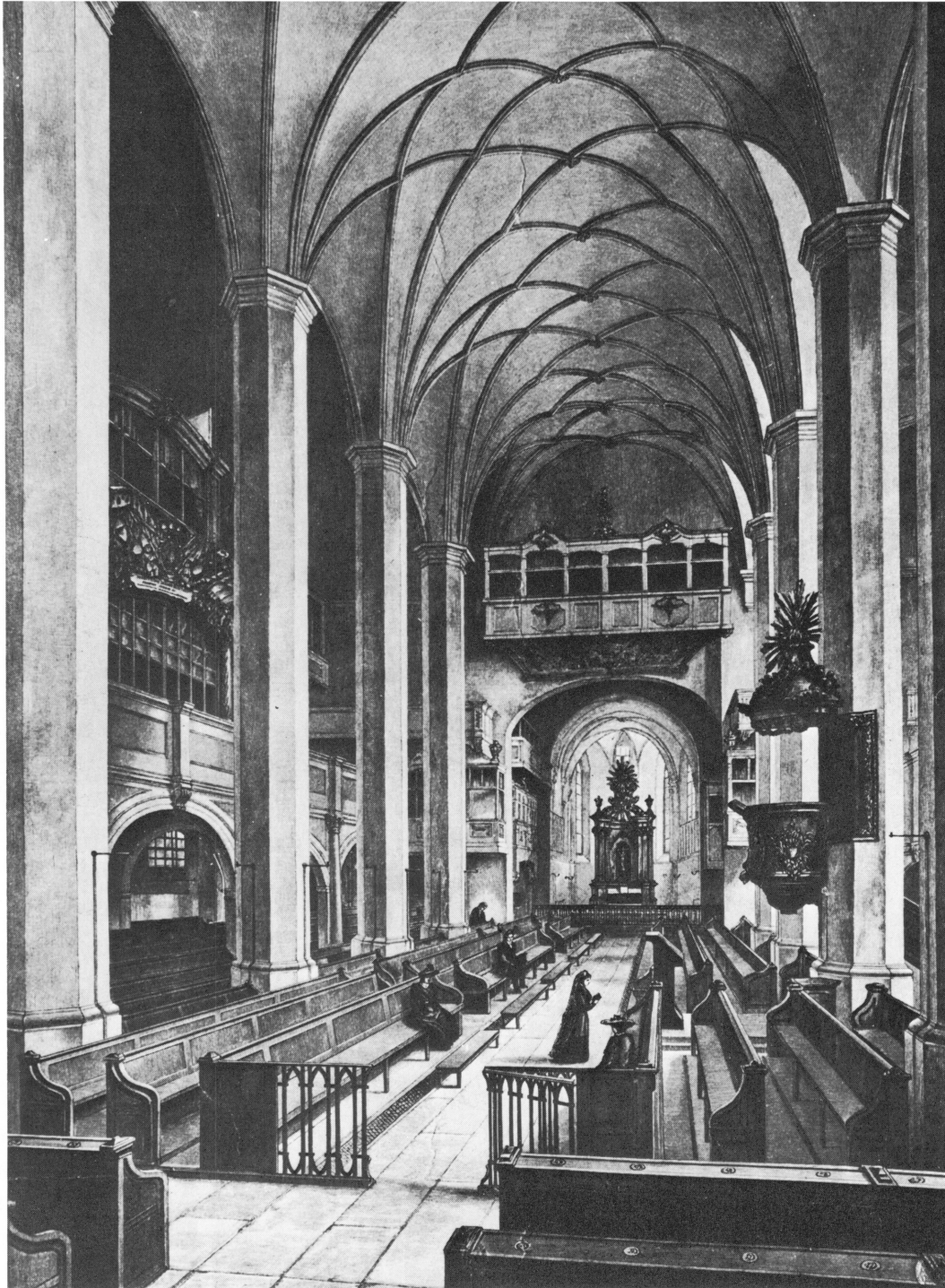
If composers generally wrote their music with a particular building type in mind, the question we must also address is the extent to which architects consciously designed their buildings according to particular musical-acoustic needs in order to achieve a “fit” between form and function. Although strictly speaking outside the scope of this book, the evolution of church architecture provides a good illustration of the effect of acoustic demands on building form. When the sermon became a major element in the Protestant service, the cubic volume of new church buildings was decreased to provide greater clarity and less reverberance, so that reflected sound would not mask the speaker’s voice. When considering the design of the London churches, Sir Christopher Wren (in a letter of 1708 “concerning an Act of Parliament passed to erect fifty new parish churches in the city of London”) emphasized that they should be small enough for everyone to hear and see the preacher. The position of the pulpit became important also, and in the alteration of St. Margaret’s, Westminster, Wren provided a large, centrally placed pulpit and galleries in the nave and aisles. Many existing churches in Germany, including the Thomaskirche at Leipzig (where J. S. Bach was cantor), were remodeled for the new services by hanging drapes and inserting new galleries near the pulpit (fig. 1.8). These modifications in turn influenced musical composition. Many of Bach’s large choral works, including the B-Minor Mass and the *St. Matthew Passion*, were written for the Thomaskirche, which must have had a reverberation time (that is, the duration of the “ringing” that is heard in a room after the sound source is suddenly stopped) as short as 1.6 seconds at middle frequencies with a full congregation.<sup>4</sup> This would have enabled the string parts to be more clearly heard and allowed brisker tempi and a faster rate of change of harmony than would have been possible in an original medieval church.

1.6  
*Interior View of Westminster  
Abbey on the Commemoration of  
Handel's Centenary, taken from  
the Manager's Box, by Edward  
Edwards (1768–1806). (Yale Cen-  
ter for British Art, Paul Mellon  
Collection)*





I.7  
 The choir, St. Paul's Cathedral:  
 engraving, 1706. (Dean and  
 Chapter of St. Paul's Cathedral)



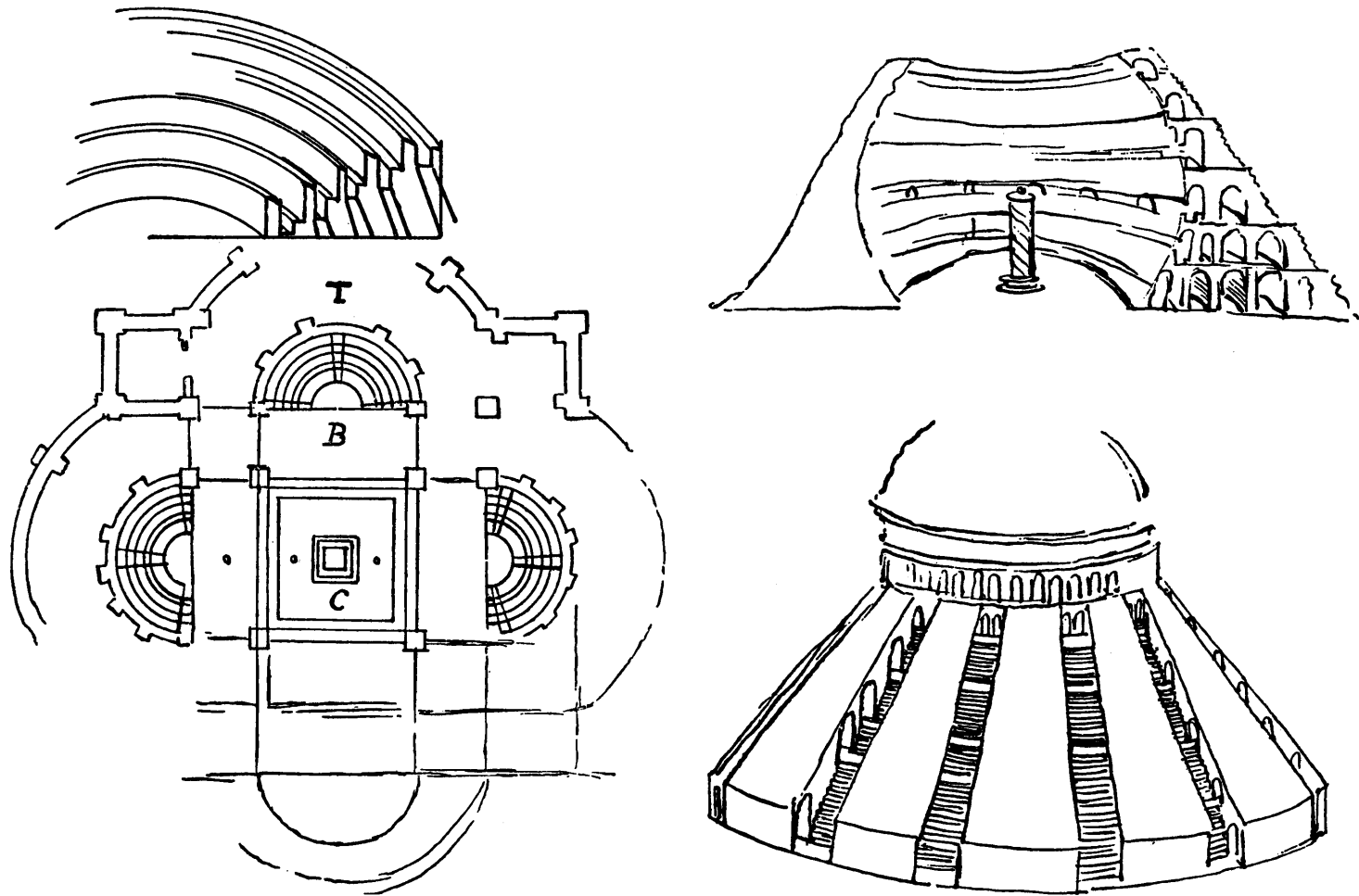
1.8

Interior of the Thomaskirche before the 1885 reconstruction. When the Lutheran service was introduced, before the time of Johann Sebastian Bach, the acoustics were altered by the introduction of drapes and balconies, in order to increase the intelligibility of speech. (Archiv für Kunst und Geschichte, West Berlin)

Another illustration of the way different acoustic requirements projected into three dimensions can result in different building forms is provided in a group of sketches by Leonardo da Vinci (fig. 1.9) depicting a building containing “theaters for hearing mass” (*teatri per ułdire messa*) and another building labeled “place for preaching” (*loco dove si predica*).<sup>5</sup> The former, with its musical function, has a centralized plan consisting of three amphitheatrical banks of seating, the curved forms of which are expressed on the outside of the building. The seating areas are set back from the central platform and enclose it on three sides. The “place for preaching,” on the other hand, brings listeners as close as possible to the speaker, who stands on the top of a raised column-like pulpit, reached by a spiral stair. Surrounding the speaker are six tiers of galleries, equidistant from the speaker, giving the building a spherical interior. Access for the audience is via staircases climbing up a conical exterior, so that the outside of the building presents the image of an “inside-out amphitheater.” The design is remarkable for the involvement of the audience, for it provides excellent sight lines and a direct sound path to every seat.

Until the late nineteenth century, notably with Sabine’s experimental work in the United States and the publication in England a few years earlier, in 1877–1878, of *The Theory of Sound* by Lord Rayleigh, little was understood about the principles of room acoustics. Acoustic successes, when they occurred, were due to a combination of intuition, experience, and luck, both in overall planning and in the use of construction materials. For instance, architects advocated to good effect, but without understanding the scientific principles involved, that theaters and opera houses should be lined with thin wood paneling, which absorbs the boomy medium- to lower-frequency sound so as not to mask the detail of both the elaborate aria and the *recitativo secco*. Concert halls, on the other hand, were generally constructed of thick, sound-reflective plaster, which is necessary for the fuller tone required in orchestral music. Antonio Galli-Bibiena’s stone interior for the Teatro Communale at Bologna (1756–1763) eventually had to be altered because it was considered too reverberant.

But the main ingredient was luck, and the generally fine reputation of the older concert halls and opera houses that still exist is undoubtedly helped by the process of natural selection. (The even greater posthumous reputation that halls tend to acquire can rarely be matched, in buildings old or new!) As Leo Beranek pointed out in his classic survey of auditoria, *Music, Acoustics and Architecture*, “Good and bad halls exist in every age, and good and bad halls have probably been built in every period. It is more than likely that the old halls that are still standing are among the best that were built. Very few halls that compared badly with their contemporaries are still with us. In fact, poor halls are often destroyed or replaced before they are 50 years old, as Boston’s most recent Opera House



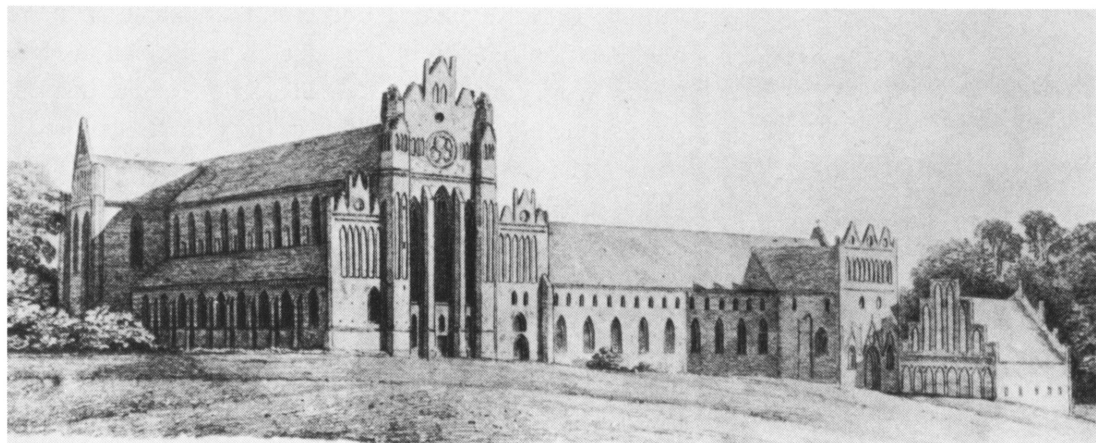
I.9  
 Plan for “theaters for hearing  
 mass” (*teatri per ułdire messa*)  
 (left) and section and exterior  
 view of a “place for preaching”  
 (*loco dove si predica*): sketches  
 by Leonardo da Vinci. In the  
 latter, the preacher stands on  
 top of the column, equidistant  
 from every listener in the galler-  
 ies. (Institut de France, Paris)

(1909 to 1958) and New York's Italian Opera House (1833 to 1839) remind us."<sup>6</sup> In this way most of the major European cities and the older centers in North America have acquired a more or less adequate legacy of different types of performing facility, each suited to a particular purpose. Besides being from time to time upgraded, this specialized "stock" of auditoria is also occasionally added to. In East Germany, for example, the answer to the problem of redundant churches—at Rostock University and Halle—and former monasteries—at Frankfurt an der Oder, Magdeburg, and Chorin—has been to convert them into specialized concert halls for oratorios, organ recitals, and other suitable musical forms. The ruined monastery of Chorin, romantically situated in a forest one hour's drive from Berlin, is a notably attractive center for summer concerts (fig. 1.10).

In provincial European and younger North American cities, however, one major hall must often suffice for many uses—for speech as well as music. And as twentieth-century economic demands for large audiences have substantially increased the average size of concert halls, the contemporary musician is presented with the dilemma of how best to achieve a satisfactory live performance, particularly of music from the baroque and Classical periods. Consider, say, the mismatch of a 21-piece orchestra playing Haydn symphonies on baroque instruments in a concert hall holding 3,000 listeners. The visual sense of involvement with the music is reduced, together with the emotional impact: the orchestra sounds "quieter" than in the small concert halls for which Haydn wrote his music. And not only is the lower sound level significant in itself: when an orchestra plays at *forte* level in a compatible-sized room, strong sound reflections can be heard from the side walls and to some extent the ceiling as the music "fills the hall." This criterion of "spatial impression" (*Raumlichkeit*) has recently been identified as significantly important to the enjoyment of

## 1.10

The ruined monastery of Chorin, near Berlin: drawing by Karl Friedrich Schinkel. The building has been converted into a center for summer music, with the nave of the church, open to the air but roofed over, serving as the main concert space. (Staatliche Museen, East Berlin)



a live concert, and this is reduced when the orchestra is unable to achieve a full-bodied *forte*, as the early sound reflections seem to be confined to the stage area instead of coming from all directions.<sup>7</sup>

Jürgen Meyer, the German acoustician, argues that a closer impression of Haydn's original orchestral sound, in terms of loudness, instrumental balance, and spatial impression, is gained in a modern concert hall by carefully scaling up the size of the orchestra (within reasonable limits), commensurate with the size and acoustic characteristics of the hall in relation to the original scoring and the halls for which Haydn wrote his symphonies.<sup>8</sup> For example, because the new Musikhalle, Hamburg, has a weaker bass response than any of the original "Haydn" concert halls, it was estimated that the balance of sound could be corrected for different symphonies by substantially increasing the bass section of the orchestra relative to the upper parts. Adjustments in total orchestra size were also worked out for the same hall, relative to the acoustics for which the particular music was written, to compensate for differences in loudness and spatial impression. For example, the woodwinds (except the horns) might be doubled for certain works and, for London Symphonies nos. 102 to 104, which were composed for the highly responsive and relatively reverberant concert hall at the King's Theatre, might even be tripled. Another compensation for the large concert halls of today is that some instruments, such as the horns, are significantly louder than their eighteenth-century counterparts. The composition and style of the orchestra can thus be adapted to come as near as possible to the original sound picture in the changed acoustical conditions of today's concert halls.<sup>9</sup>

The designer's approach to the problem of matching the auditorium with the style and type of performance, from the late 1950s onward, has been in a number of cases to provide halls with variable acoustics. The adjustability may be mechanical: the quantity of sound-absorptive material and even the volume of the room can be varied to alter the reverberation time, as at the Jesse H. Jones Hall in Houston, Texas, and at the experimental workshop L'Espace de Projection, at the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in the Centre Georges Pompidou, Paris. Alternatively, there is the less "pure" electro-acoustic method of "assisted resonance" using loudspeakers, as at the recently completed Hult Center for the Performing Arts in Eugene, Oregon, and at London's Royal Festival Hall, where it was earlier used as a remedial measure.

Acoustic design is, in the words of the American acoustician Theodore Schultz "an art, not a science," being a matter of musical judgment rather than simply a scientific process. Let us for instance consider the opposing demands of two contrasting musical styles: the Romanticism of the nineteenth century, as applied to the works of Berlioz, Liszt, Wagner,



and so on; and the music of the Classical period, roughly from 1750 to 1820, when the great symphonies of Haydn, Mozart, and Beethoven were written. Music of the Romantic period is best heard in a relatively reverberant hall, such as the Concertgebouw, Amsterdam, and the Musikvereinssaal, Vienna. The blending effect of reverberance is like the brush strokes in an Impressionist painting, which obscure the subject so that the onlooker is induced to project his senses and emotions into the work in order to perceive the image. The shimmering music of Debussy, its colors sparkling and ethereal, even seems to possess its own “built-in” reverberance.

The formally structured music of the Classical period, unlike music of the Romantic era, which predominantly expresses emotion, has reason and clarity as its basis. The detail (such as ornamentation, which embroiders the basic melody and provides “lustre”) and the subtler emotional characteristics of eighteenth-century music were revealed to advantage in the small, often overcrowded concert rooms of the time, such as the Holywell Music Room, Oxford, and the Hanover Square Rooms, London, which were sometimes lined with thin wood, as was the Altes Gewandhaus, Leipzig, where acoustic clarity was gained by a short reverberation time and extreme acoustic intimacy. It is evident that the nature of the music of this period calls for less “distortion” in the acoustics of the hall. In the nineteenth century, as concert halls became larger and consequently more reverberant, they remained suitable for such music, provided the hall was sufficiently narrow in width for there to be strong lateral sound reflections to retain high definition with the fuller tone, as at the Grosser Musikvereinssaal, Vienna.<sup>10</sup>

Because each style and type of music evolved in a particular acoustic ambience, and because the taste of listeners naturally differs, there is thus no single optimal form for auditoria where a range of music is to be performed. As Cremer and Müller say in their handbook *Principles and Applications of Room Acoustics*, “there exist particular solutions that have proved themselves.”<sup>11</sup> Nevertheless, “for theatres and concert halls . . . such a standardization would be the end of architecture. Variability in these facilities is attractive not only for the eye but also for the ear. This variability is also justified by the reasonable assumption that the acoustic optima, if they exist at all, are at least rather broad so that it becomes most important simply to avoid exceeding certain limits.”<sup>12</sup> Moreover, the science of acoustics must never lose sight of the qualitative end product. Like a musician’s technique, it is a means to a musical end, not an end in itself. The acoustics of an auditorium may serve either to reveal the musical detail or to create a general wash of sound color like the blurred image created by broad brush strokes in a painting; the size and manner of the brush strokes depend on the style of the work to be heard.