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The idea of functional form was an important inspiration in the twentieth century. This article explores both the science and the mythology of forms supposedly related to sound.

Acoustic form in the Modern Movement

Peter Blundell Jones and Jian Kang

The architects of the Modern Movement in the late 1920s found new sources of form through the pursuit of technical and functional issues in design. They sought shaping agents in functional organization, in the admission of light, in efficiency of structure and construction, and many other physical issues of this kind. At the same time, they felt the need to escape from traditional rules of architectural composition involving Classical orders of columns, symmetry and axes. They were ready to discover a new and surprising identity for buildings precisely to defy the historicist conventions that until then dominated architecture as a cultural tradition. Acoustics is an area in which many interesting claims were made, and some famous Modernist designs were supposedly formed, or at very least inspired, by acoustic forces. These historical instances beg the question whether acoustics is really a legitimate and helpful formal determinant of buildings. Perhaps instead, the acoustic arguments put forward by architects to justify their formal choices were just convenient alibis. This is a far more complex issue than at first it seems.

Nature provides some important clues for acoustic form, particularly in the anatomy of the ear, which by the beginning of the twentieth century was well known (Beyer, 1999). The form of the horn is there suggested, and it is replicated in reverse role by musical instruments, particularly brass. The shapes of guitars and violins, perfected through long craft evolution, are closely related to their acoustic performance even if nobody can explain finally and completely how they work. But even if the pattern of resonances that distinguishes a Stradivarius defies analysis, the difference of size between a violin and a double bass is utterly obvious. Clearly there are rules of size, shape, and material which must be closely followed for any instrument to perform as it should: even the distinctive form of so mechanical an instrument as the grand piano is the direct result of the asymmetry of its stringing, with low notes to the left and high to the right.

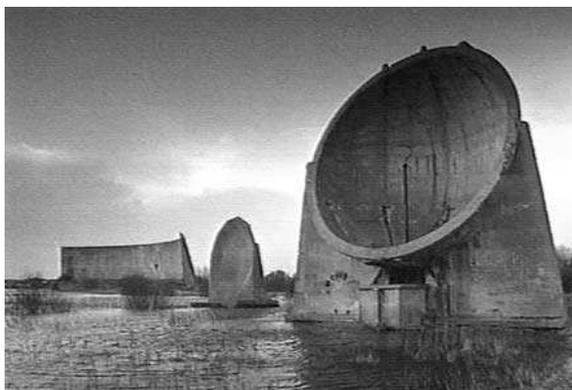
In architectural design, acoustics has received

attention at least since the period of the ancient Greeks, but architectural acoustics had been the most neglected branch of the science of sound before Sabine's pioneering work at the beginning of the twentieth century, especially on reverberation (Sabine, 1964). Since then the field of architectural acoustics has grown in breadth and in depth.

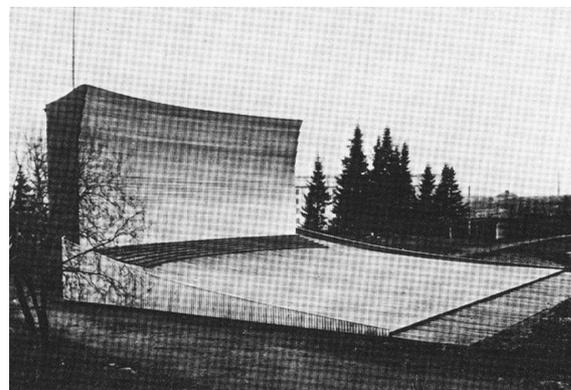
Simple form, unique function

The most simple and straightforward acoustic instruments are those with a direct and unique function: the horn of the wind-up gramophone commonly follows as closely as possible an exponential curve (Beranek, 1954), its length and mouth geared to the lowest frequency it is meant to reproduce – usually it was not big enough for effective bass reproduction. Even more directly and monothematically shaped were the east-coast wartime listening stations intended to pick up the sound of approaching enemy aircraft: walls of concrete shaped parabolically to focus sound waves on one small receiver [1a]. In fact, this reflection law has been understood for centuries and been applied in various buildings (Hunt, 1978). Perhaps the nearest architectural equivalents to these examples are the specially shaped bandstands designed by Alvar Aalto (Schildt, 1986) [1b], intended to shelter and celebrate the presence of a band performing in the open-air, while at the same time reflecting its rearward and upward acoustic radiation towards the audience. The bandstand designed by Gunnar Asplund and Nils Einar Eriksson for the Stockholm Exhibition of 1930 was 11 metres high and had a fairly simple folded form clad in plywood (Rudberg, 1999) [1c].¹ In addition to increasing sound level, the reflections are useful for providing a degree of reverberation, and are beneficial in allowing the performers to hear each other. The raised bandstand is helpful for allowing a larger audience to receive direct sound. Here acoustic intentions and the curves obtained through the new technology of plywood could come together in a glorious synthesis.

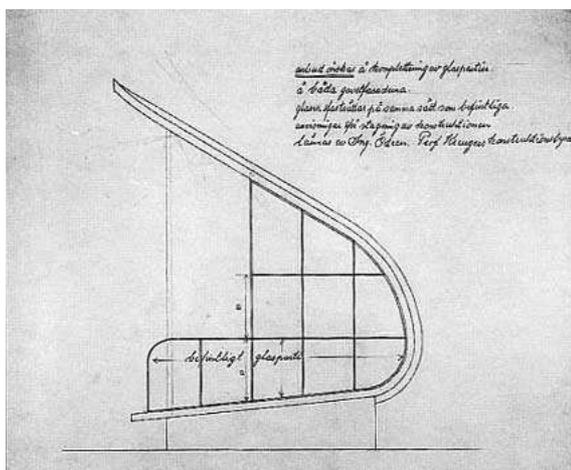
A recent reinterpretation of the same theme is the beautiful bandstand at Bexhill by Niall McLaughlin



1a



1b



1c



1d

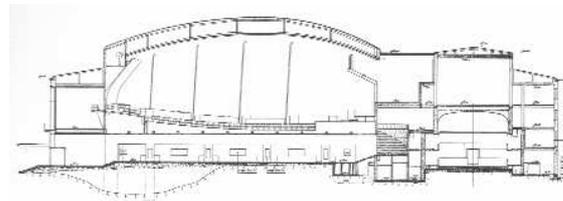
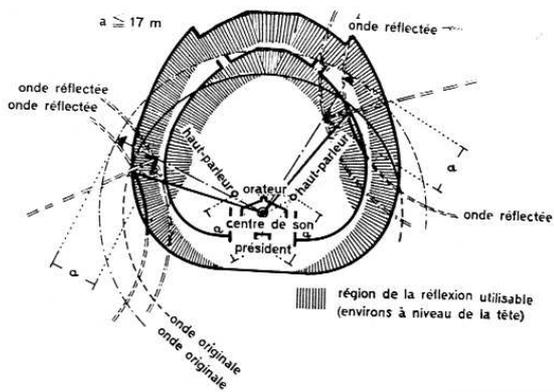
added next to Mendelsohn and Chermayeff's De la Warr Pavilion (Dawson, 2002) [1d]. The curved form is more complex in keeping with current tastes and design methods including computers, but the architect claims once again to have been inspired by acoustic requirements. Design started with models in the form of sheets of paper, and the acoustician advised some reshaping to avoid unwanted foci. Advanced acoustics software was then used to simulate the sound field and to check the angle of the shell, making sure there was no coloration and focus by the convex part. However, the procedure did not extend to comparing different versions, so there was no selection strictly on an acoustic basis, and structure was also influential. One can conclude that there was certainly significant acoustic input, but the form was not fully driven by acoustic criteria.

Generators of form

The operation of the bandstand might seem logically extendable to the concert hall and other large auditoria, but the acoustic behaviour of fully enclosed spaces is much more complex. Nevertheless, Modernist architects seeking a functional justification for everything were quick to seize on the idea that acoustic principles could be a generator. A famous early example is Hannes Meyer's design for the League of Nations Competition of 1927, which he backed up with technical looking plans and calculations (Schnaidt, 1965) [2]. The

acoustic consideration played a key role in determining the shape of the hall. The main principle was to use direct sound and keep the first reflections within 50m, which conforms with today's design theory. However, the claimed optimal shape of the hall is somewhat far-fetched, for the analysis was only based on a single source position. With multiple sources and/or different source positions as would occur with a discussion, the reflection patterns would be different. Furthermore, there is a possibility that the curved shape would cause a focus, concentrating sound from speakers and possibly also audience noise. Experience with oval buildings such as London's Albert Hall suggests that Meyer's Congress Hall would have been an acoustic disaster. Interestingly, Le Corbusier's design for the League of Nations Competition also used a curved surface, although only for the ceiling (Barron, 1993). It was rather surprising that reverberation, the most important index in auditoria, appeared not to be considered in Meyer's design, despite the fact that Sabine's reverberation theory had been available for about 20 years, and despite mention of absorbent materials, such as Sabine's acoustic tiles, in the design description. These would not necessarily have helped much, for at that time effective public address systems had yet to be developed, and the acoustic absorption required to reduce stray reflections could have rendered speakers inaudible.

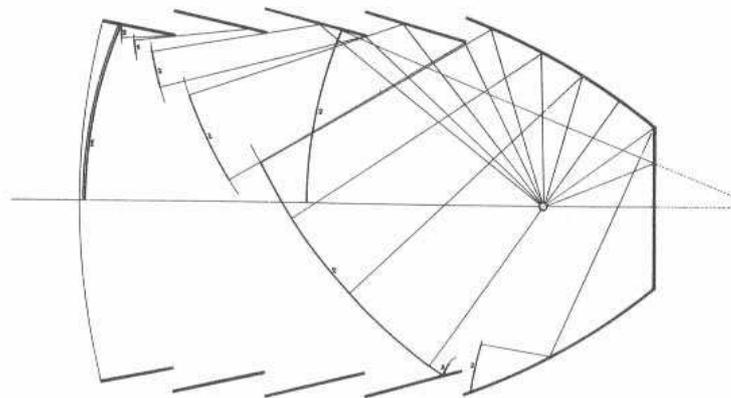
More credible in both theory and practice – it was



3a

1 Simple structures with direct and unique functions
 a East-coast wartime listening station
 b Intended to shelter and celebrate as well as to reflect: bandstand by Aalto
 c 11m high and plywood clad: bandstand by Asplund and Eriksson
 d Complex and computer designed but acoustically inspired: bandstand at

Bexhill by Niall McLaughlin
 2 Seeking a justification for everything: acoustic analysis in Hannes Meyer's design for the League of Nations Competition of 1927
 3 Credible in theory and practice: Nils Einar Eriksson's concert hall at Götaplatsen in Gothenburg
 a Section
 b Acoustic analysis



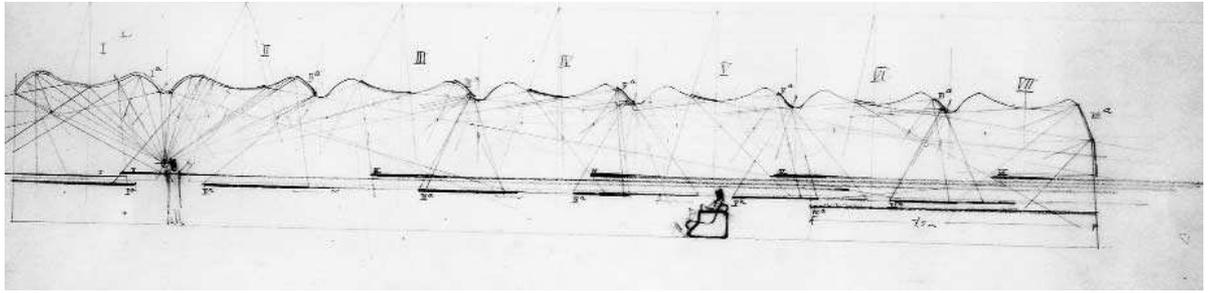
3b

actually built – is Eriksson's concert hall at Götaplatsen in Gothenburg completed in 1935 (Caldenby, 1992) [3a and b]. Eriksson was a young architect of 32 and, as one of Gunnar Asplund's principal assistants on the Stockholm Exhibition of 1930, a new convert to Functionalism. He won the competition of 1931 by proposing an egg-in-a-box scheme whose interior surfaces were deliberately shaped for appropriate reflections and to avoid standing waves, the canted planes of the sides providing convenient entrance points and responding to the radius of the seats. The side walls, ceiling and back, never horizontal or vertical, were all finished in maple-veneered plywood panelling, about 25mm thick, the wooden bracing behind the panels being randomized and securely held in place on heavy frames to prevent resonances. These measures seem to have worked well precisely in the terms intended, and the hall has always been regarded as acoustically successful, though with a linear layout and an audience size of only around 1300,² the acoustic problems were admittedly not very pressing. The reverberation time is about 1.6 seconds at middle frequencies, which is optimum for orchestral and chamber music in this size of hall. The visual effect of the acoustic policy was much more striking internally than externally, for only the roof of the hall can be seen and only from some distance, rising above the brick box of the main shell whose Neo-Classical front was an answer to the urban context.

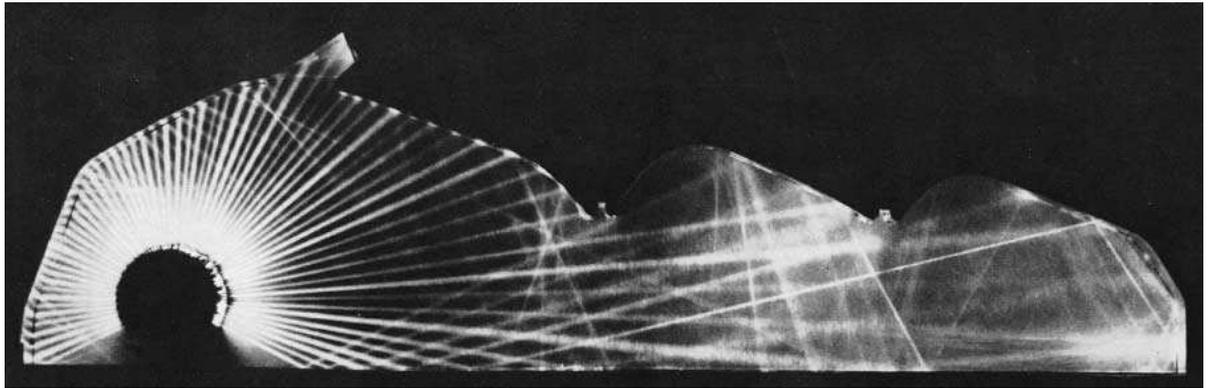
Form of elements

Good acoustics in a concert hall depends on not only the basic form, but also on the form of acoustic elements in Eriksson's hall. The reflector over the stage has been changed several times due to the acoustic requirements. In the design competition entry only an organ grill but not the original sound reflector was shown. After the competition, it was decided to build one of the greatest concert organs in Northern Europe. To hide the huge pipes that had to be placed in the hall, a sound reflector was built. As some problems had been reported with orchestral balance, when the orchestra was expanded in the 1980s, the reflector was also extended and re-shaped (Beranek, 1996). However, there were some further complaints about the balance problem on the stage. After a 10-year investigation including subjective evaluation and objective measurements by a number of acousticians, in 2001 a new reflector system with vertical transparent baffles was installed. With the new system, the orchestral balance has been greatly improved by the diffuse scattering from the reflectors (Rindel and Jordan, 2002).

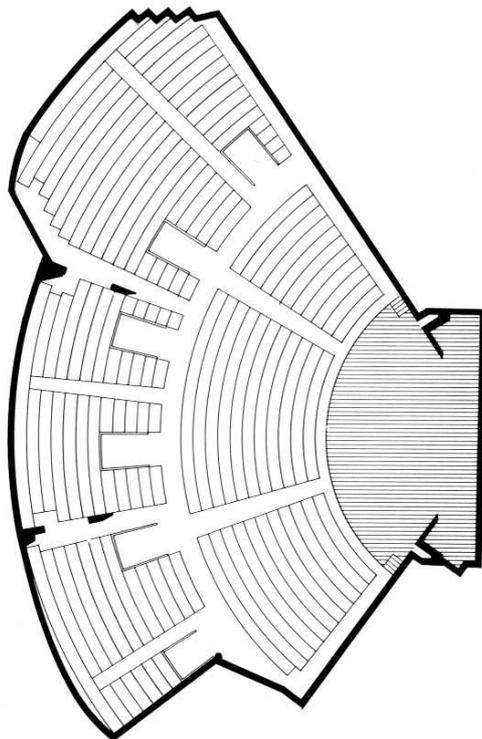
Perhaps the most celebrated acoustic form of the early Modern Movement is Aalto's wavy lecture hall ceiling at his Viipuri library (Blundell Jones, 2002) [4], also completed in 1935. Not only is this an important detail in one of his greatest masterpieces: it also proved a forerunner for his later design vocabulary, recurring in many forms. There is little doubt that



4



5a



5b

Aalto was sincere about the acoustic intentions, as a series of sections have been preserved which explore the paths of reflections between speaker and audience, for various different positions of the speaker. Furthermore, leading historians of the period were prepared to take him at his word. No less a figure than Sigfried Giedion (1966) claimed:

'Of course, the architect himself can prove, with meticulous acoustic diagrams, that the undulating form he gave the ceiling enables sound to reach the human ear more perfectly. Here, therefore, scientific reasoning and artistic imagination have merged to free architecture from that rigidity which is today an ever-present menace.'

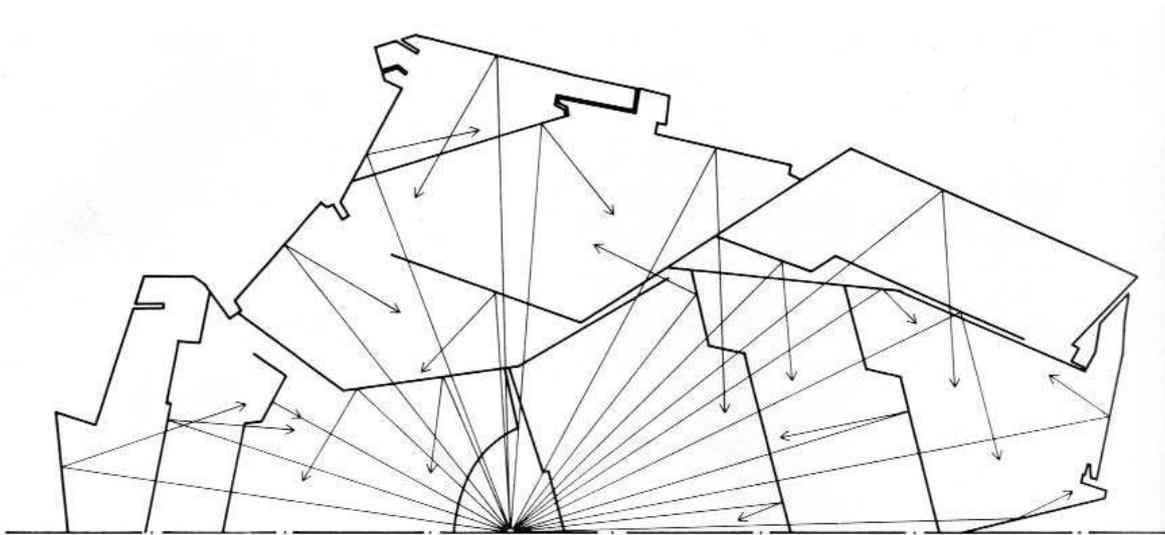
However, the lecture hall was only so long and thin because Aalto decided to fit it into a linear office wing whose width was governed by the upper floor, so he brought the acoustic problem on himself. Furthermore, it is doubtful whether the original intention is achieved at all. A fundamental mistake of the design is that the wavy ceiling was intended to reduce the sound attenuation along the length, or in other words, to create a relatively even sound field, but according to recent research (Kang, 2002), the effect of such a ceiling form is likely to be just the opposite. The wavy ceiling provides more diffuse reflection, and it has been theoretically and experimentally proved that with diffusely reflecting surfaces the sound attenuation along the length is greater than that with smooth surfaces. This is because with diffusely reflecting surfaces, some sound energy is redistributed towards the source due to backscattering. The wavy ceiling might not have been entirely useless in acoustic terms, however, for the curves covered up a series of downstanding structural beams that would have made acoustic compartments with unwanted resonances: also the

4 The most celebrated acoustic form of the early Modern Movement: acoustic design of Aalto's wavy lecture hall ceiling at his Viipuri library
5 Aalto's later work with acoustic reflections
a The light model of the Vuoksenniska

Church of 1951
b Kulturitalo Hall, Helsinki of 1958: plan
6A widely imitated acoustic success: Scharoun's Berlin Philharmonie 1956-63
a View of auditorium
b Sound reflection distribution in cross-section



6a



6b

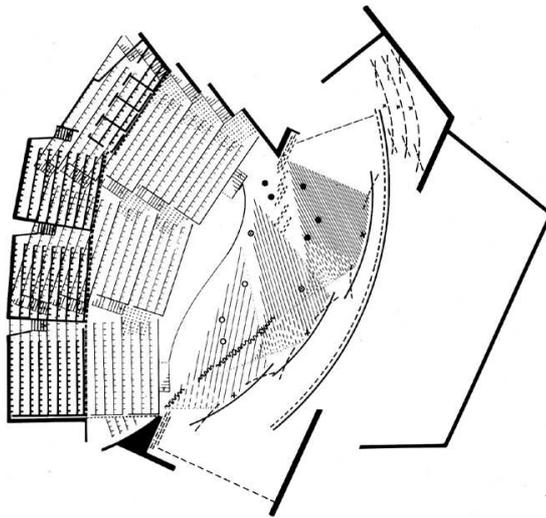
lack of parallel between floor and ceiling would disperse reflections rather than allowing them to build up into standing waves with the hall only partly occupied. Thus if the ceiling is less than credible as a positive acoustic measure for the reflection paths it creates, it is at least effective as a negative measure, for preventing other acoustic problems that might otherwise have arisen.

As a form in the building, the ceiling was important in many ways, and Aalto made it surprisingly visible on the outside through the tops of the windows that lit the room. On the one hand it introduced a new way of making layered ceilings with contrasted levels – something found throughout the later work – while on the other it introduced a vocabulary of curves that Aalto went on to exploit imaginatively in almost endless ways.

Related to the human body and its movements – for example, his ergonomic handrails – these curves related also to the new technology of laminating wood used in his furniture. In composing buildings they allowed special incidents and points of focus, nearly always in contrast with the rectangular norm. That these curves seemed by their designer naturally given – or at least obedient to natural laws – was important for their justification whether or not they actually worked acoustically.

Larger works by Aalto

Aalto continued to work with the idea of acoustic reflections. They occur again in the light models of sections from his Vouksenniska Church of 1951, and he published them to prove his concern (Fleig, 1990) [5a]. Light models are useful for examining first- or



7

7 A precursor to the Philharmonie: Scharoun's design for the national theatre, Mannheim, 1953

8 Scharoun's later unbuilt concert hall projects
a Saarbrücken: completely

asymmetrical and divisible into two. Plan b Pforzheim: close to symmetrical but its parabolic walls could provide a strong sound focus. Plan c Diagrammatic plan in which each shade represents a different

sound pressure and demonstrates the possible focus effect in the hall

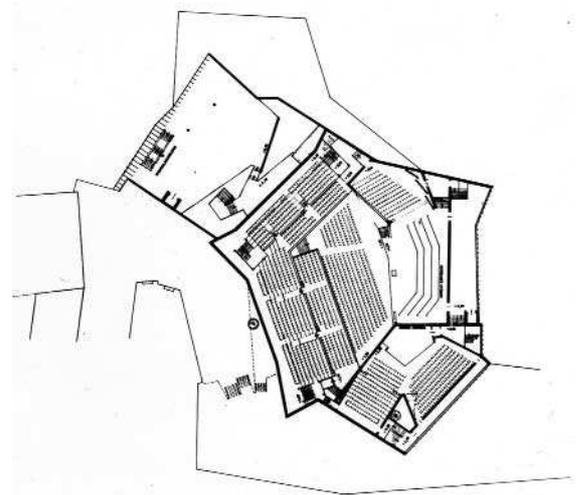
9 The Chamber Hall at the Philharmonie: plan. As successful as the larger hall, it also suffers from lack of lateral reflections

second-order reflections, as shown in Aalto's photograph, as well as for investigating sound intensity distribution by using luminous intensity. Their disadvantage is that it is difficult to obtain information about reflection arrival times and consequently about reverberation, which is more important than early reflections in lively spaces like churches. Moreover, the use of light models in acoustics is limited to high frequencies since the wavelengths of light are very small in comparison with room dimensions.

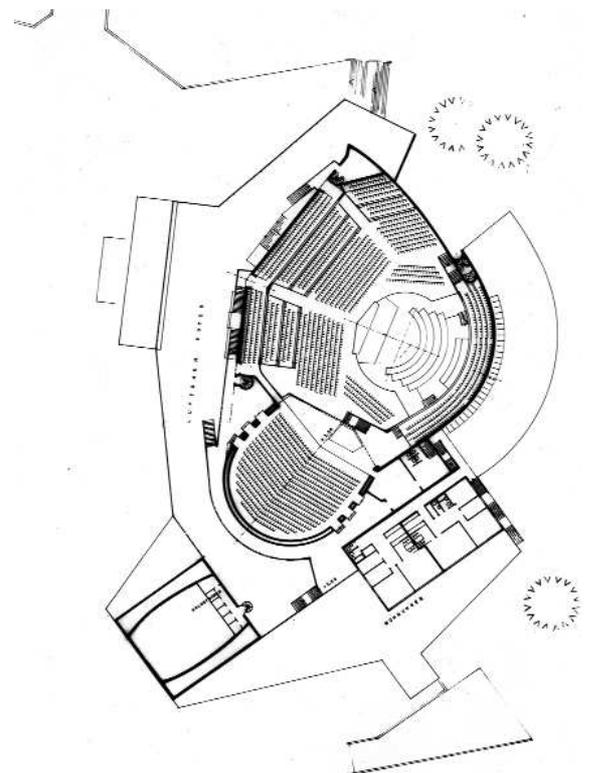
When Aalto came later to build concert halls whose acoustics really matter, he was unlucky. Neither the Kulturitalo Hall, Helsinki (Beranek, 1962) [5b], of 1958 nor the later Finlandia are regarded as good halls acoustically, despite their beautiful interiors and social atmosphere. The middle frequency reverberation time in the Kulturitalo Hall is only one second under occupied conditions, which is too short for music, although it seems that the hall sounds better than its reverberation time would suggest, perhaps because the ceiling provides short initial-time-delay gaps (Beranek, 1962). However, these wide fan-shaped halls were found to have a more fundamental problem: they lack surfaces close to the orchestra for lateral early reflections, a requirement that was not adequately understood at the time of their design (Barron, 1993).

The Berlin Philharmonie

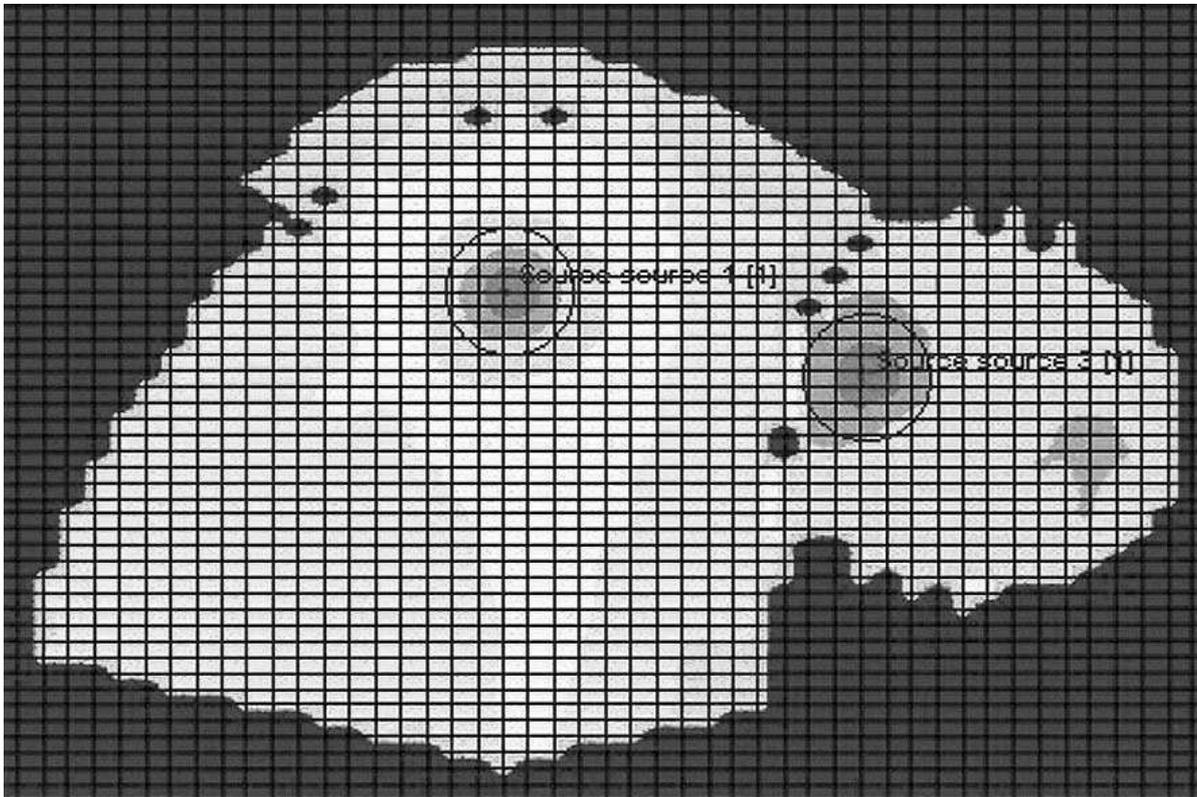
The most successful radically new concert hall by a Modernist at that period was Scharoun's Berlin Philharmonie 1956–63, which is regarded as a great success acoustically and has been widely imitated (Blundell Jones, 1995) [6a and b]. The acoustic design of the hall also reflected the significant development in architectural acoustics after the Second World War, especially in the aspects of diffusion and early reflections. Although Scharoun was among the most liberal of Modernists in his readiness to experiment with form, there is no clear case like Aalto's Viipuri ceiling (to which Scharoun paid late homage, incidentally, in the lecture hall at Bremerhaven



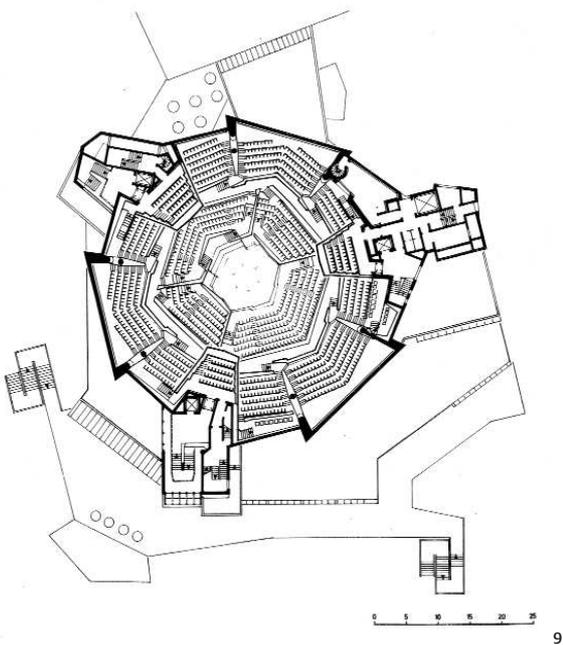
8a



8b



8c



9

Maritime Museum, 1969–76). Scharoun's early works reveal no conclusive cases of acoustic form and his middle period was restricted to private houses. Only after 1945 could he become actively engaged with large public buildings, beginning with competitions for the Leipzig opera and the Stuttgart Liederhalle, both of 1949. Although he won the latter, it was not built and there is no particular evidence of acoustic thinking. Ideas about theatre developed with the winning but unbuilt Kassel design of 1952 and the brilliant unplaced Mannheim competition project of 1953 (Blundell Jones, 2002) [7]. Here, radical ideas about staging and the relationship between players and audience were developed, and in the Mannheim design came the division of audience into separate terraces that was to prove one of the greatest innovations in the Philharmonie, but still there was no obvious concern for acoustics. All this changed with the Philharmonie, and Scharoun's close collaboration with the acoustician Lothar Cremer (1905–1990).

Cremer had a remarkable feel for the acoustic properties of buildings, and as he walked around them he saw them in acoustic terms. When he was first invited by Scharoun to participate in the development of the design, he was sceptical. The idea of music in the round might be socially desirable, but so many instruments are directional in their output, their resonant surfaces facing frontwards and upwards. The cellist's body tends to screen its acoustic radiation to the rear, for example, and singers are worst of all, for not only must one hear the directional voice: one also wishes to see the face.



10a



10b

But Scharoun was adamant: when people gather around music in the street, they make a circle, because it is far more important to be close than to be on axis, and the whole group comes together as a community. The traditional linear layout of the concert hall separates 'producers' from 'consumers' and sets them in opposition. The hierarchical layouts inherited from the nineteenth century express the social hierarchy that they used to enforce, with aristocrats in boxes and plebs in the gods. He sought to bring everyone together in a new and more compact arrangement. Cremer struck a bargain with Scharoun: if they were to pursue the difficult and risky idea of music in the round, Cremer must be allowed freedom to make the forms work acoustically. Scharoun agreed and a fruitful collaboration ensued: Cremer said later that Scharoun was the best architect he had ever worked with, for he always managed to change things to accommodate the acoustician's demands without destroying his own concept.³

The Philharmonie immediately looks more acoustically formed than Scharoun's earlier works. There are first of all large-scale acoustic measures, such as the sweeping double curve of the ceiling, intended to disperse the sound rather than concentrating it as a concave one would do. Of course a concavity of a kind is produced between the two curves, which is one reason for the hanging reflectors that are such an essential part of the hall's 'skyscape'. In plan, too, acoustic measures are evident. The end walls each avoid reflecting sound back down the axis, one skewed, the other inverted.

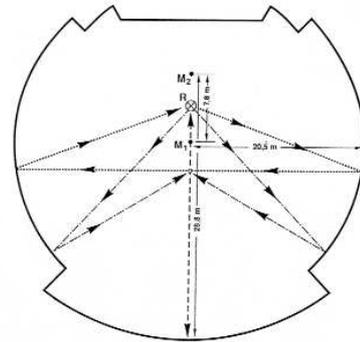
Acousticians' drawings showing reflection paths do seem credible, and even in detail the reflective properties of every surface were considered. There is much more: the control of reverberation time, including some manipulation with added resonators, and a careful choice of materials and surfaces. The measured reverberation time with full occupancy is two seconds at middle frequencies, and 2.2 seconds at 125Hz. The low frequency reverberation is well-balanced, mainly using the pyramid-shaped Helmholtz resonators seen on the ceiling, although some have suggested that this is a little overdone (Beranek, 1996). Finally, though, consensus of opinion attributes the acoustic success of the hall to something hardly understood at the time: the presence of the seat fronts created by Scharoun's terraced accommodation of the audience. Cremer undoubtedly made good use of these, assuring that they faced appropriate directions to provide useful early reflections, but they were a by-product of the social policy developed by Scharoun for his Mannheim Theatre project. Acoustically, it was a happy accident.

Later projects by Scharoun

Scharoun designed two further halls as competition proposals, neither taken up. That for Saarbrücken of 1957 (Blundell Jones, 1995) [8a] followed close on the heels of the Philharmonie competition and carried two innovations: it was completely asymmetrical and it proposed a hall divisible with a huge moving partition into two. There is no great evidence of acoustic input, and indeed the collaboration with



11a



11b

¹⁰Acoustics are also important in buildings like libraries such as the Faculty of Law building in Cambridge (Foster and Partners, 1995) a Full-height entrance hall providing a direct sound path between the basement coffee area and reading rooms. This has now been corrected by the use of screens

b Interconnected reading areas enclosed by curved wall off which sound reflects
¹¹ A case where negative acoustic effects cannot be solved by electronic intervention only: Günter Behnisch's Parliament in Bonn
 a The circular chamber with its walls of glass
 b Diagram illustrating the focus problem

Cremer on the Philharmonie was only just starting. Since the 'in the round' layout was rejected due to the requirements for occasional film shows and lectures, the directivity problem of the orchestra became less of a concern, although the seating area is still at a very wide angle, especially when the partition is open. In terms of early reflections, it appears that the design principle is similar to that of the Philharmonie. Early reflections are mostly from the ceiling and the walls in the seat area. As in the Philharmonie, there is a lack of lateral reflections, but the importance of lateral reflections has only been demonstrated since the late 1960s.

The other concert hall design for Pforzheim of 1964 moved in a different direction from the Philharmonie (Blundell Jones, 1995) [8b]. Though seating is still 'in the round' only a very small proportion is behind the orchestra. The large hall is close to symmetrical, and the side walls and the wall behind the orchestra may be used to provide early reflections. A possible problem is that the parabolic walls could produce a strong focus. This has been demonstrated using a ray-tracing based computer program (LMS, 2001), as shown in 8c, where each shade represents a different sound pressure level with a step of 3dB. In the simulation, the two halls are separately considered and in each hall there is a point sound source positioned on the stage. In the small hall, a strong focus area can be clearly seen.

The Chamber Hall at the Philharmonie completed after Scharoun's death by Edgar Wisniewski (Blundell Jones, 1998) was known to Scharoun only as a sketch, but already had an interesting form acoustically

(Blundell Jones, 1995) [9]. Intended for chamber groups, it was given a regular hexagonal podium, but it becomes more irregular as you move outwards, the back walls being differently angled and set at different distances from the centre, thus preventing the flutter echoes and standing waves that occur with even and parallel surfaces. The irregularities of the hall, together with the long reverberation time of 1.8 seconds, helped to create a rather diffuse field. The ceiling is again convex, with hanging reflectors at the centre. The uniformity of the sound field is further enhanced by the reflections from the ceiling to far-flung seats. The main change of design between the version Scharoun knew and that built is the sinking of the podium to produce more reflective fronts close to the musicians. The acoustic consultant was again Cremer, followed by Nagel, and the hall is as successful acoustically as its big brother, though the risk was less due to its comparatively smaller size with 950 seats. However, the two fundamental problems of 'in the round' layout, the instrument directivity and the lack of lateral reflections, can be clearly heard from the different seats around the stage (Barron, 1993).

Non-acoustic spaces

The concert hall represents the epitome of acoustic work in a positive sense, becoming in cases like the Gothenburg hall and the Philharmonie almost a musical instrument in itself. But acoustics is not only important in performance spaces: it also has a strong effect on 'non-acoustic' spaces like libraries, museums and dining halls. Comfortable acoustic conditions may go unnoticed by users, but poor acoustics can damage the whole design. In the Faculty of Law building in Cambridge, by Foster and Partners, a full-height atrium forms the focus of the building. The atrium links the different levels visually, creating a feeling of spaciousness [10a]. However, soon after the building was opened, strong complaints were received regarding the noise disturbance between floors, especially the noise from the basement coffee area reaching the library reading areas on the upper terraced floors. In addition to the direct sound, the reflections off the curved glass wall, which characterizes the building form [10b], also contributed considerably to the overall noise level. As a result, some transparent panels had to be installed to acoustically divide the

space. Following acoustic disasters of this kind in a number of award-winning buildings, acoustic comfort in 'non-acoustic' spaces is receiving increasing attention.

Another interesting case where negative acoustic effects required drastic intervention was Günter Behnisch's Parliament at Bonn (Blundell Jones, 1993; IBP, 1993). The architects wanted to make a transparent building to place parliament 'within the world' and to leave it open, so the walls were of glass, and they daylit it from above with a sophisticated multi-layered roof to regulate the light. The seating layout for the politicians was circular [11a], in a bid to state the equality of members and parties, but surrounding galleries for press and visitors made a square, appropriately detached from the decision-making circle. While the creation of a room large enough for members alone might just about have worked without amplification, the larger space involving press and visitors could clearly not avoid a public address system, and Siemens were engaged at an early stage to develop a sophisticated computer-controlled device to coordinate and balance all members' microphones, relaying the results to a series of hanging speakers, and dealing with time-delay problems. Thus the acoustic treatment of the space became regarded as largely a technical problem, with a range of technical adjustment built in to the electronic relaying system.

On the first day the new parliament opened there was a crisis. Members had assembled for a debate and the Deputy Speaker opened proceedings, but shortly afterwards the whole PA system shut down. A recess was called, attempts were made to sort things out, members were recalled, but it failed again. A quick decision was made to reopen the session after lunch in the old waterworks that had been used till then as a provisional home. Irritated members told the press that the new building was a shambles, that the microphone worked better in any cowshed. Asked to comment, Behnisch said the problem rested with Siemens and their system. Later, however, it was discovered that human error was also to blame. The parliamentarians had asked for a panic button to be installed to kill the PA system in case things got out of hand, and this had accidentally been triggered, perhaps by the cover of the Deputy Speaker's handbook. A Siemens representative had tried to help, but had been kept out by the strict security staff.

Whatever the chain of blame for this unfortunate event, it could not have been more public, and threw a spotlight on the building's acoustic performance, so that when it was used again it was not considered good enough, and electronic adjustments failed to compensate for the fact that the building's

background acoustic was basically too live. More seriously, the glass walls created a strong acoustic focus in the middle of the hall, where speakers, microphones and loudspeakers were positioned [11b]. With a conventional building it would have been relatively easy to add some absorbers to reduce reverberation and avoid the focus effect, but the glass box had to remain transparent, and the ceiling to continue its transmission of daylight. The beautiful wooden floor was soon sacrificed for blue carpet to obtain some damping, but it was not enough. More importantly, absorbers on the floor could not solve the focus problem. To increase sound absorption in walls without visually obtrusive additions, the acousticians came up with the idea of gaining damping by using an additional layer of micro-perforated acrylic-glass inside the existing glass wall. With an air space between the layers, a resonant system is formed (Kang and Fuchs, 1999). By making thousands of carefully designed tiny holes using a laser technique, sufficient acoustic resistance was provided while the transparency remained. Micro-perforated sound absorbers had been used before in other buildings, but the transparent micro-perforated panel was an innovation for the special requirements of this building. As with the Philharmonie, this example shows how novel acoustic design and technologies often arise out of difficult architectural requirements.

Useful as inspiration, insufficient as determinant

Attractive though it may be, acoustic form is elusive, and only really reveals itself in simple and extreme cases like the gramophone horn. If useful as an inspiration, it is insufficient as a determinant in buildings, even such acutely important ones as concert halls. Despite the success of the Philharmonie as a model, the continuing popularity of the shoebox form shows that it remains competitive, the best examples being considered acoustically excellent. And in the argument between the two types, the social experience remains paramount: it is for its sense of togetherness and its atmosphere that the Philharmonie is loved by its fans and hated by its opponents. The varying occurrences of acoustic form in the Modern Movement also suggest that it has been closely related to the development of acoustic theory and technology, reflecting ideas about how things might work as much as how they actually do work. Preventative or negative acoustics is becoming increasingly important in an ever noisier world, even if its application is usually invisible and taken too much for granted. Here too there is much useful work for acousticians to do and for architects to learn from.

Notes

1. See Rudberg 1999, p70: Nils Einar Eriksson later designed the Gothenburg Concert Hall that is considered below.
2. 1371 originally and 1286 after the renovation in 1985.
3. All this from personal conversations between Peter Blundell Jones and Lothar Cremer at the opening of the State Library, Berlin in 1979, and subsequently at his home in Miesbach.

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