By a lucky coincidence, nearby Harvard University had built a lecture hall that had such bad acoustics that it was unusable. By chance, a young assistant physics professor by the name of Wallace C. Sabine was willing to take on the assignment of fixing the room so that lecturers could be understood when they spoke. Sabine devised a way of measuring reverberation time by playing an organ pipe in the room and measuring how long it took the reverberation to die out after he stopped. He then enlisted the help of a paid assistant to borrow the heavily padded seat cushions from Harvard's Sanders Theatre and trot them across Harvard Yard to this lecture hall.

During the night he would conduct his experiments. With his organ pipe and a stopwatch, he noted how much the addition of various numbers of cushions to the room would reduce the reverberation time in the troubled lecture hall. Then, before morning classes began, the seat cushions would be returned to Sanders Theatre. This went on for several years and became something of a joke around the campus with these seat cushions being marched back and forth from building to building night after night. But, in the end, Sabine had found the first mathematical formula for predicting reverberation time based on the volume of a room and the amount of acoustical absorption within the room. Reverberation time was defined as the length of time it takes a sound level to drop 60 decibels once the source is turned off.

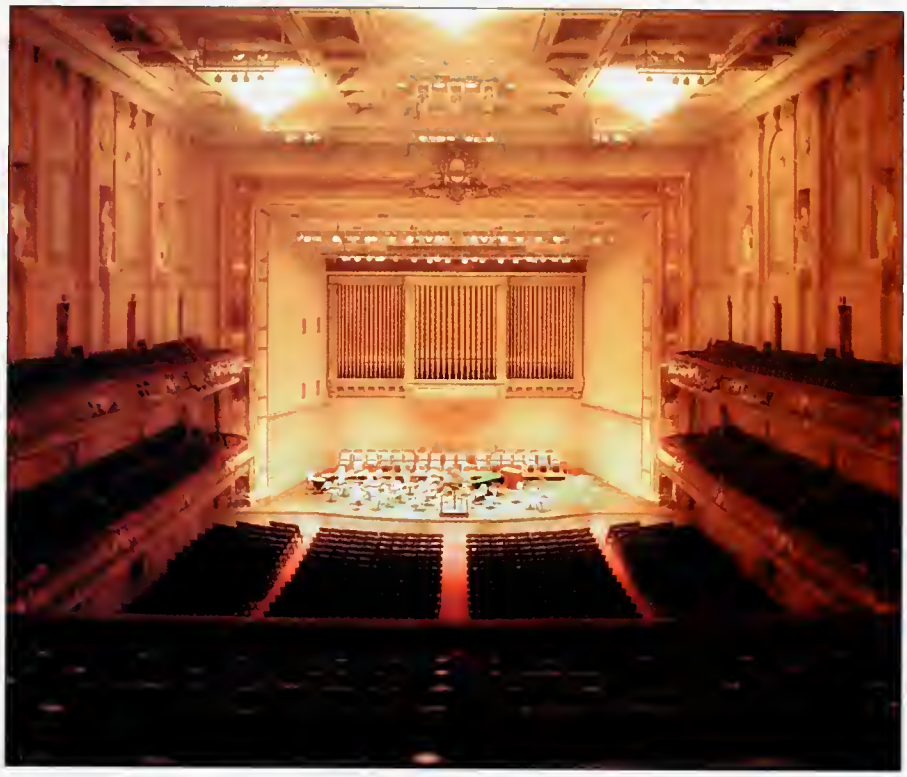

**Figure 1:** *Boston Symphony Hall.*

## THE DAWN OF MODERN ACOUSTIC SCIENCE

In conversations with Higginson, Harvard's president learned of Higginson's concern about the proposed design for his new concert hall. He told Higginson of Sabine's experiments and suggested that Sabine might be able to offer some advice. Indeed, this set in motion a series of events that resulted in what many, including myself, regard as the finest concert hall in the world, Boston Symphony Hall—the first hall designed with the use of a scientific formula for reverberation time. For starters, Sabine used his new formula and found that a hall designed simply by multiplying the Gewandhaus' dimensions by 1.3 would result in a reverberation time of around 3 seconds—way too much for orchestral music. That put an end to the second design for Higginson's new hall. Still, there was the absolute requirement that the new hall have 2,600 seats.

Sabine pointed out that the old Boston Music Hall, the Boston Symphony's original home, sounded wonderful. This was a European-style shoebox-shaped hall of some 2,200 seats and an open stage at one end of the main floor for the orchestra. He suggested a new hall design that would essentially duplicate the footprint of the Music Hall but with a new stage-house extension. This would free up enough floor area to bring the seat count up to 2,625. Sabine then used his new formula to calculate the volume of the hall required for the desired reverberation time. It was then simply a matter of setting the ceiling height to create the needed volume.

It is a testament to Sabine's genius that he was able to design a stage house that would work so well. But, in retrospect, we now understand the workings of concert halls well enough to realize

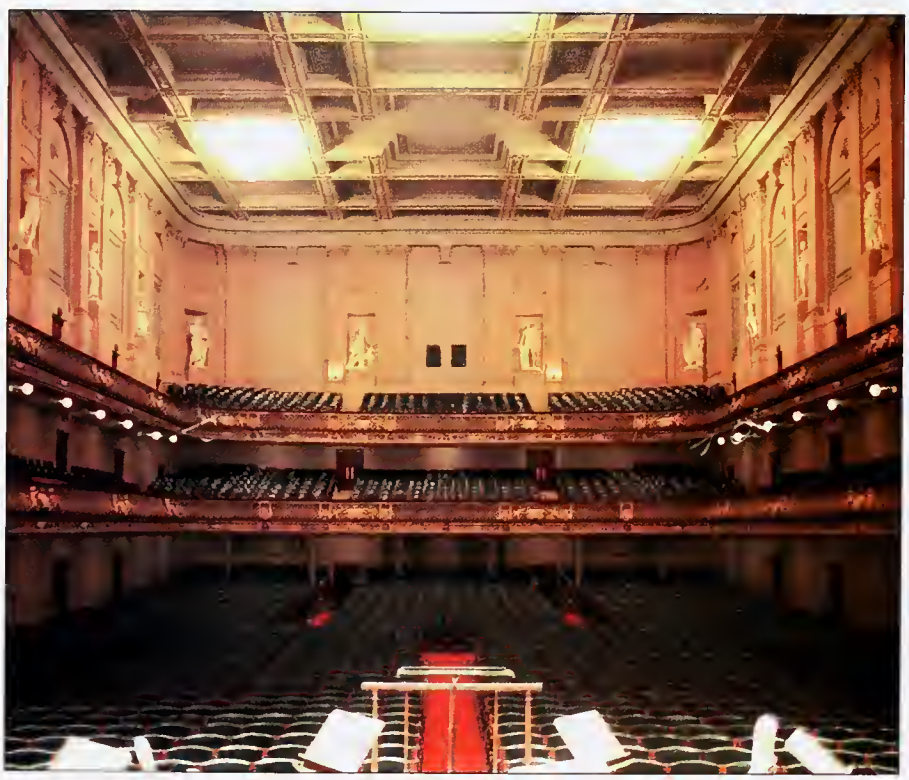

**Figure 2:** *Boston Symphony Hall.*