LEO BERANEK

An Interview Conducted by

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Interview: Leo Beranek
Interviewer: Michael Geselowitz
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Geselowitz: This is Michael Geselowitz of the IEEE History Center. I'm in Cambridge, Massachusetts interviewing Leo Beranek as part of our oral history program. We interviewed Leo back in 1996—the interview was conducted by Janet Abbate—and he has remained very active since then. Now we would like to catch up on the important work he has been doing since that time. Leo, the last interview, which was done in 1996, ended with you leaving your TV station in 1982 at which you were the CEO at Channel 5 here in Boston. I'd like to pick up at that point and ask you to describe what you did in what normal people call "retirement," and then later in the interview we'll move to the exciting acoustical work you are doing today.

Beranek: Thank you very much. Following my tenure at Channel 5, four activities kept me fully occupied. In 1980 I was elected a member of the Board of Directors of the Wang Laboratories. Wang produced computers for use by office secretaries in corporations and its business was growing like wildfire because there initially was no competition. In the Board meeting I brought to Wang fresh ideas on management of research and wide area networking, both carryovers from my years at BBN. Wang's principal product was the VS computer, to which a number of "dumb" terminals, were connected, each of which was comprised of a keyboard and a cathode ray tube. A secretary at each terminal could do data processing and word processing. Compared to what they could do with a typewriter, secretaries were elated because changes in text could be made easily and whole sections instantly interchanged. In addition, spread sheets could be constructed. Wang's sales were primarily made to the heads of departments in corporation, rather than to corporate headquarters. The larger of these companies usually had IBM mainframe computers which met their financial and corporate computing needs. But, Wang's rapid growth suddenly met an obstacle. In late 1981, IBM introduced the PC computer. It had a keyboard and cathode ray tube, a central processor, a large memory, and a floppy disk recorder. An important factor in the immediate success of this new PC product was its ability to connect to the IBM main frame using a proprietary IBM SNA network. Wang's salesmen soon reported that the main frame managers in corporations wanted to control all computational activities, a goal they could achieve by purchasing computers that could be connected to the main frame.

In 1983, Wang asked me to become a half-time consultant to the product development department of the company hoping I could help them adapt their computers for connection to IBM's main frames. I was assigned to work with two of their most skilled engineers. Wang choose not to make a clone of the PC, which was a mistake, but rather to continue to use the VS and associated dumb terminals. This meant that a way had to be found to get around the proprietary SNA network. Incorrectly, we were advised by many computer gurus that IBM would be forced by international standards to adopt the X.25 protocol in addition to their SNA protocol for connecting outside devices to their main frames. With that advice, we quickly developed a way of connecting the VS to the mainframe via the X.25 protocol. However, IBM bucked the international trend and stuck with SNA, meaning that the X.25 protocol was of no help. Without a viable main frame connection, sales of Wang systems to large corporations slowed precipitously by 1986. In time, Wang found a non-SNA protocol for connecting to the mainframes, but it came too late. In 1984, I tried to get Wang to manufacture a competitor to the Apple MacIntosh portable computer. Because Wang's sales force was oriented toward secretarial needs, the decision was made by Dr. Wang to develop a stand-alone electronic replacement for the typewriter. That development was completed and manufactured, but it was clumsy and found few buyers. By 1986, Wang's fate was set and a few years later the company went bankrupt. I ceased being a consultant and resigned from the Board of Directors that fall.

In 1989, I was asked by a nominating committee to become the sole candidate for the presidency of the American Academy of Arts and Sciences. I accepted, with the understanding that it would be a half-time activity.

Geselowitz: Is that a membership organization?

Beranek: It is an honorary society in which the exiting Fellows elect a number of new Fellows each year from over twenty fields ranging from math, science and engineering on one end to music and philosophy at the other.

Geselowitz: Do the Fellows elect the officers from among themselves?

Beranek: That is correct.

Geselowitz: Did you have a staff to help and support you?

Beranek: Yes. There is an Executive Director and staff to handle membership. Other members of the staff act as secretariats to the study projects that are ongoing. There are frequent meetings accompanied by meals so there is a kitchen contingent, and a buildings manager. *Daedalus* magazine, a quarterly, which is produced inhouse, requires an editor and a production staff. Fundraising is handled by a development office. Finally, there must be a business manager and his/her staff.

My term of office was expected to be three years but by special membership vote I was asked to continue for an additional two years. To make the organization financially viable, I raised money for their endowment fund, cut down on expenses, raised dues, and changed the health system. I prevailed on the elections committee to reduce the average age of new members and to raise the percentage of women inductees.

My third activity was with the Boston Symphony Orchestra, Inc.

Geselowitz: How did you get involved with the Boston Symphony?

Beranek: My involvement with the Boston Symphony started back to the late 1950s. My company, Beranek and Newman – Newman and I were equally responsible for this project– were hired to study ways to improve the acoustics of Tanglewood's Koussevitzky Shed in Lenox, a town in western Massachusetts. The acoustics in that 6,000 seat hall were poor for almost any kind of composition except church music. It was highly reverberant and there were no means for introducing clarity. In BBN's new design, we increased the clarity by means of a canopy, comprised of triangular panels, which was hung over the stage and the front part of the audience. Also, we designed a new stage enclosure that mixed the sounds of the instruments properly and enabled the musicians to hear each other better. Also, we changed the upper rear wall of the Shed to reduce an echo. The renovated Shed was such a success that the Board of Trustees invited me in 1968 to be a charter member of a newly formed Board of Overseers. In 1977 I was elected Chair of the Board of Overseers.

In December 1979, the President of the BSO asked me become head of a newly formed Resources Committee which was to oversee all fund raising activities BSO's monthly newsletter, December 1979, stated that the BSO's annual deficit was over $1 million (actually $1.3 million) which had to be taken out of the endowment fund. If this course of action persisted for long it would soon lead to a collapse of the orchestra because the endowment fund was barely over $8 million. Within two years after my appointment, with the enthusiastic concurrence of the President and Managing Director, I brought about erasure of the deficit by cutting operating expenses, raising ticket revenue, and increasing annual donations. Also, working with Mrs. John Bradley, the endowment was increased by over $20 Million. I became known in the greater Boston community as a fundraiser. I was elected Chairman of the Board of Trustees in 1983 which position I held until I reached their mandatory retirement age. I am now a Life Trustee. I might add that the Boston Symphony Orchestra has received my enthusiastic financial support through the years.

Geselowitz: You apparently also got re-involved with Harvard in this retirement period.

Beranek: That's right. Somebody invited me to be a candidate for Overseer at Harvard, The Board of Overseers is their senior governing body.

Geselowitz: Was this after you established your reputation as a fundraiser?

Beranek: Yes.

Geselowitz: Being an alumnus myself and knowing how Harvard operates I had to ask that.

Beranek: But, I was not put there for fundraising. I was probably nominated because I was a scientist and because the committee may have thought that I had been a successful administrator and would help make Harvard run a little better. Each year there are five new overseers elected and each has a six-year term.

Geselowitz: Was that from 1984 to 1990?

Beranek: Yes. I was surprised that I got elected, because there were ten candidates. One explanation is that I was well known in the Greater Boston area—I had been a professor a Harvard and MIT, President of Beranek and Newman, President of a television station and was active in Boston's cultural activities. The Board of Overseers was composed of fine people, among them were Al Gore and Jerry Wiesner. The most important job for the Overseers is to maintain Harvard's academic standards. Visiting committees are set up with members selected from all over the country and with the involvement of at least one overseer on each visiting committee. The overseers prepare reports that go to the president of Harvard and to the chairman of the appropriate departments. Those reports help maintain Harvard's academic quality'.

Geselowitz: Is it a combination of overseers and experts in a particular field that visit a department or unit who analyze how the entity stands nationally or internationally within that field and whether it meets Harvard standards? Is that why the overseers play a part in the visiting committees?

Beranek: Yes, you have said it all. I was on four visiting committees to: Physics Department; Loeb Drama Center; Business School, and Biology Department. I also served on Advisory Committee on Science, Technology and Public Policy at J. F. Kennedy School. This wide range of memberships made use of my prior experience.

Geselowitz: They were very fortunate to have someone with your breadth of experience. Was this period of the late '80s and early '90s also when you got involved with the Massachusetts Historical Society?

Beranek: Yes. I became a Council member is 1986 and a Vice President in 1989. Today I am an Honorary member.

Geselowitz: Okay. Is there anything else of which I am not yet aware during that period? So far, following your position at Channel Five, you have described a little intermezzo at Wang. Then the American Academy of Arts and Sciences took at least half of your time and you had other things going on, so that probably filled your "retirement" time?

Beranek: Exactly.

Geselowitz: I would really like to know the story of how you got back into your roots of acoustical consulting.

Beranek: As soon as my consultancy at the Wang Laboratories ended, I decided to return to the activities that I genuinely enjoyed. Back in 1962 I had written a book on concert halls and opera houses called *Music Acoustics and Architecture.*

Geselowitz: It might still be in print. I know it is an important book.

Beranek: It's not in print, but it can still be purchased from resellers. My basic training was in acoustics, I understood the theory, and my mind was still working, so I spent three years full time going over the recent literature and visiting concert halls in several countries. By 1990 I felt that I knew most of what had happened in the intervening 18 years. Accordingly, I prepared a paper that was published in the Journal of the Acoustical Society of America, entitled, "Concert Hall Acoustics—1992." In 1972 the Japanese had translated and published my 1962 book, with some updating that I prepared. People interested in music knew my name. In the mid-1980's the Japanese national government decided to build a large center for performing arts in Tokyo on an 11 acre plot in the vicinity of the Shinjuku Rail Station. They underwrote a Western style opera house, a drama theater and an experimental theater. An industrial group was invited to build a concert hall, a skyscraper and a shopping mall. The total amount of money spent was about $2 billion. Both wanted the best acoustics in the world. The architect urged them to engage me and I was invited to Tokyo 1989 where I was interviewed and engaged to start work on the opera house. I was given the title, Acoustical Design Consultant. The architect also hired a laboratory to help me with the construction of models and the making of acoustical measurements. That entity was the Takenaka Research and Development Institute. The concert hall project did not get into full swing until late 1991. The opera house and concert hall opened in 1997 within six months of each other. I decided that I would insist on their adopting my recommendations, or else I would resign, a procedure that I should have followed in the case of New York's Lincoln Center.

Geselowitz: Would you say something in terms of the history of acoustical consulting as an emerging science and the problem with architects not understanding or appreciating the role of acoustical engineering in general? Then we'll get back to the opera house.

Beranek: There is general agreement that the three great concert halls of the world are the Vienna Vereinssaal, the Amsterdam Concertgebouw and the Boston Symphony Hall. The Boston hall was opened in 1900 and the others are even older. Architects as designers of concert halls differ from the designers of violins. Whoever wants to make a great violin tries to construct a fiddle as near to a Stradivarius as possible. Instead of copying a great hall, which would seem logical, both the architect and the owner generally want to make an architectural statement—a building that will receive great media attention, like the Balboa Museum in Spain. Architectural awards are not given for how a hall sounds but rather for how it looks.

Often, after the architect has conceived something unique and impressive, he engages an acoustical consultant with the statement, "Can you add some things to the design to give it great acoustics?" But, there is one acoustical principal that is inviolate: Every hall that looks different sounds different. If you make a violin that's square or triangular it won’t sound like a Stradivarius. There are situations like Philharmonic Hall in New York where I received a bad reputation. I had convinced the architect that he should copy Symphony Hall as closely as possible. Actually, he agreed and we worked together to perfect the design. The results were published in the *New York Times* in December 1969, along with the architect's visual rendering. The sketch was labeled “Final Design.” If that had been built, the hall would have been a great success. After that date the building committee and the architect changed the hall dramatically. It did not work out.

In the case of the Japanese halls there was no such trouble. The Tokyo Opera City concert hall is a good example. They started right off by agreeing to copy as much of Boston's Symphony Hall possible, but the architect wanted to make a statement of some kind, provided that the hall would still have great acoustics. What the architect decided, and I agreed, was to make the bottom part of the hall rectangular up to just above the second balcony as in Boston. Above that he wanted to replace Boston’s flat ceiling with a tall pyramid. This pyramid is not symmetrical like those in Egypt. Instead, the base sat on the rectangular part of the hall and the architect took hold, so to speak, of the peak and pulled it over to just above the front of the stage. This made the ceiling segment above the stage very steep and made the ceiling segment, which started at the peak (above the front of the stage) and extended to the rear of the hall, very long.

Geselowitz: I get it.

Beranek: This long ceiling surface was a problem. No one had experience with that design. I went back to acoustics basics and concluded that the orchestra would hear an echo from that surface. In addition, in the great halls, more of the reflected sound from the orchestra comes from the side walls than from the ceiling, that is to say, laterally reflected sound is more pleasant than sound from overhead. So something ought to be put on that large ceiling surface that would throw the sound to the upper sides of the rectangular portion, from where it would be reflected back to the audience laterally. If thrown to the sides, there would be no echo. A modern structure called a QRD will do just that. The QRD treatment was applied to the large overhead surface and it turned out to be an excellent solution. The hall sounds as good as Boston Symphony Hall. In fact some of the people who perform there say it is now their favorite hall. The Tokyo Opera City Concert Hall was written up in a large article with illustrations in color in the *New York Times* in April 2000 which was headed, "Art + Science = Good Music." The article even had a side box that said, "Vindication: Beranek after his troubles with the Philharmonic Hall has done something that has worked out very well." Now, let's go on to the opera house.

Geselowitz: Were there particular challenges with the opera house?

Beranek: The architect's plans for the opera house was not as troublesome, except that one had to be sure that the singers' voices could be heard clearly above the orchestra sound which emanates from the pit. In many opera houses the orchestra dominates the singers. The challenge was to design a room that emphasizes the singers and not the orchestra. I decided to do something that is not found in any other opera house. I had the architect construct a sort of a trumpet shape around the proscenium opening. The shape does not look particularly like a trumpet bell, but the idea is there. Above the proscenium there is a large curved surface that slopes upward and that resembles a large trumpet bell. The balcony fronts near the stage are also curved to give a sort of trumpet shape. That means that the sound that expands outward from the singers hits those surfaces and the reflections from them, in turn, are distributed over the audience areas. Contra wise, the orchestra gets no benefit from the trumpet-like surfaces. All the other surfaces, namely the ceiling and the balcony fronts, join with the trumpet surfaces to distribute the music uniformly over the audience. In the hall, there are neither dead spots nor hot spots. The opera house that has been highly praised and in my opinion has acoustics that are not exceeded elsewhere in the world.

Geselowitz: I think I have heard that said, though I have not been to Japan.

Beranek: That was their first Western music opera house. Their other opera venues are Kabuki or Noh houses.

Geselowitz: Their traditional opera houses.

Beranek: It's a very different thing. In Tokyo the First National Theater is for Kabuki and Noh. Our opera house was at first called the Second National Theater, but later they renamed it the New National Theater.

Geselowitz: Would you say their Kabuki Theater is well situated acoustically for its style of music?

Beranek: Yes. I found no fault with those theaters, mainly because they are not large and the reverberation is small, which makes the voices clear and loud. A small room with too much reverberation sounds like a bathroom. If you get the reverberation under control, a small room can be perfect.

Geselowitz: You mentioned that there were at least three great acoustic halls completed by the end of the 19th century. Would you like to comment on how in the pre-modern age—before modern technoscience—an architect came upon such superb designs without the tools that you had at your disposal?

Beranek: I'll give you a quickie on the old European halls and then spend some time on Boston Symphony Hall, partly because its development is well documented. The three great old halls of Europe have been the Musikvereinssaal in Vienna, the Concertgebouw in Amsterdam and the old Gewandhaus in Leipzig which was bombed out in World War II. All are rectangular shoeboxes and are really just expansions of palace ballrooms that were successful venues for classical music. All three opened before 1890.

Boston Symphony Hall opened in 1900. It is said to be the first hall where acoustical science was applied. That is true, but more was involved than science. Major Henry [Lee] Higginson owned the Boston Symphony privately until 1918. He paid all the deficits and hired the conductor and the players. He chose the architect for the new hall, Charles McKim of the firm McKim, Mead and White. McKim was famous because of the Boston Public Library, the U.S. General Post Office in New York, buildings at the World's Fair in Chicago in 1893 and many others. He wanted to produce a unique hall. His big plan was a Greek theater like the one at Epidaurus with a roof over it. Drawings were made and a model was built that was located on exhibit in the Boston Public Library. Higginson took the photographs and drawings of the model to Europe in an effort to find out how leading conductors and musicians would react to the design. He knew Europe well because he had studied piano in Vienna for several years and also had become acquainted with many musicians because of his hirings for the Boston Symphony Orchestra. They advised him not to do a

Greek style theater, because similar designs had failed to have satisfactory acoustics. When asked for their recommendation, their consensus apparently was the Gewandhaus, a 1680 seat hall. Higginson obtained plans for it and brought them back to Boston. He asked McKim to design a rectangular shoebox shaped hall like the Gewandhaus but to hold 2600 people. His suggestion was to increase all the dimensions by about 30 percent which automatically would mean that the audience areas [1.3 squared] would hold 2600 people. Higginson set up a building committee and the committee decided that the hall should be fireproof. This meant a plaster interior instead of the usual wood. Wood, unless very thick, absorbs bass.

At this time, an unexpected happening occurred. In October 1898, a young assistant professor at Harvard, Wallace Clement Sabine, had just completed a study of the acoustics in a dozen halls at Harvard University and from his findings had made recommendations to correct inferior acoustics an auditorium in the old Fogg Art Museum. The president of Harvard, Charles Eliot, was very pleased with what Sabine had done, and during a meeting with Higginson, he recommended that Higginson talk with this young fellow. Higginson soon met with Sabine. He was very taken with this convincing, sincere, good looking man, and he showed Sabine the plans for the blown up version of the Leipzig hall.

Sabine took the plans home and made some calculations using a new formula that he had developed as a result of his Harvard study. He found that the calculated reverberation time for the proposed hall would be much longer than what he calculated for the Leipzig hall. He reported to Higginson that the ceiling had to be lower by about 30 percent to achieve the proper reverberation. Another important decision was made by Higginson, namely, for visual reasons the hall must be less in width then the 77 feet of the old Boston Music Hall. These recommendations were sent to McKim. Interesting, he was not told of Sabine's participation. McKim responded in December with new drawings that showed a hall 75 feet wide, with a lower ceiling. Like the Leipzig hall, there was one balcony on each side wall and two at the rear and the orchestra was seated at the front end, with the side balconies extending over the sides of the stage. In order to accommodate 2,600 persons with these restrictions the hall had to be very long. Both Higginson and Sabine agreed that with this length the hall would have a tunnel sound. To shorten the hall, Sabine suggested that a second balcony be put on each side wall. Next, he recommended that instead of the orchestra sitting at the front end of the hall beneath side balconies, it should be put in a small stage house at that end, narrower than the main hall and without the side balconies above it.   In the space of the previous stage location, 200 seats could be placed. Even with these changes, the hall was too long. Higginson decided to reduce the row-to-row from the 36 inches that McKim had decided down to 31 inches. The hall now had nearly the length and appearance of the old Boston Music Hall. Finally, Sabine used his formula to determine the correct ceiling height to produce the desired reverberation time. McKim was not happy with these changes because the hall looked very much like a copy of the old Music Hall.

Geselowitz: Even after you got all sound exactly right then you still need to throw in a little bit of patina or something to break it up a little bit?

Beranek: Right. We use the word diffusion. Irregularities in the hall diffuse the sound. McKim had provided irregularities for visual reasons. He had planned to have niches and statues on the original Greek theater design. He also planned to have a coffered ceiling. It is not known whether he or Sabine suggested the design of the balcony fronts, but they correctly reflect the sound into the audience areas. All those irregularities give the sound a "patina." Sabine made two other recommendations that were followed. He asked that the air from the ventilation system enter the hall from the ceiling and exit via grilles in the lower side walls. This meant quiet ventilation and no disturbance of the sound. He also won an argument with the organ builder that kept the opening to the organ chamber at a reasonable size.

For the first time, Higginson let McKim know that Sabine was involved. McKim apparently expressed considerable unhappiness with these changes and Higginson arranged for Sabine to go to New York in February, 1899. During a two hour meeting, McKim accepted all of the changes, except he was adamant that the number of rows in the side balconies be three instead of four (as was suggested by Higginson) for sight reasons. In summary, a shoebox shaped hall gives the best reverberant sound. If its width is kept under 77 feet, the hall will sound intimate. Lined with plaster on concrete block, the bass is preserved. With the ceiling height set proper, the reverberation time is optimum. With statues, niches and coffers, the sound was given a proper patina. And, Sabine's design of the stage enclosure has been well accepted by musicians and conductors.

Geselowitz: Would you say that even today there is an element of luck and art to building a concert hall?

Beranek: Anything that looks different is going to sound different. Therefore the acoustics consultant has to try and insert as many feature of Symphony Hall as possible into the new design. That's what we did in the design of the Tokyo Opera City Concert Hall, yet we successfully allowed the architect to introduce a pyramidal ceiling. But not every shape can be made to sound good. If the architect won't cooperate, there probably will be trouble. A beautiful architectural design may overcome some acoustical deficiencies as is evident in Gehry's Disney Hall in Los Angeles, but there are many good seats in the hall.

Geselowitz: When you are working with the architect to develop that, is it done mainly through virtual simulation in a computer or do you actually build and test models?

Beranek: Both are very important. In the case of the Tokyo halls, I asked for computer simulations in the early stages of design, and a 10:1 model to make the final refinements. But, being in the United States, I could not do this job alone. I needed help. The Takenaka Research and Development Institute which is located in Chiba near the big airport did the computer studies, built the 10:1 model, and made measurements both in it and in the completed hall.

Geselowitz: 10:1 is a pretty big model.

Beranek: It is so large that one can stand up in it, which meant that we could adjust the shapes of every surface. In the model, a tiny loudspeaker was placed on the stage through which the music of different instruments could be played and we moved it around to different positions. Takenaka developed a little "head" that was one inch in diameter with two tiny microphones in it for ears. We were able to play music through the tiny stage loudspeaker and listen to it binaurally from the two microphones in the dummy head. We could not depend on calculations, because there was no experience to guide us in regard to pyramid shaped ceilings. We adjusted the sloping of surfaces in the hall and added such irregularities as were indicated. I wrote a book in 1996 to bring into the picture all I had learned from my study of 76 concert halls and opera houses and from the TOC work, *Concert and Opera Halls: How They Sound*.

Geselowitz: Was there a lot of overlap with your earlier book?

Beranek: I would say that about 30 percent was reused and all else was new.

Geselowitz: Have you also written articles on this? Have you gotten back to publishing your work?

Beranek: The Takenaka people and I have published a number of articles in the Journal of the Acoustical Society of America that cover our experience in these halls and in others in Japan. More recently, I have written a third book, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (Springer, 2004). It covers 100 halls and houses and incorporates all of my Japanese experience.

Geselowitz: How much of a difference did having digital equipment rather than analog equipment available for measurement and so on make from 1962 to the 1990s? Is it better to work in analog for audio since the human ear is analog? What kind of measurement equipment do you use, and has the transistor revolution impacted your work as an acoustician?

Beranek: The computer model is digital, so in that respect we used totally modern equipment. However, in the 10:1 model all measurements are basically analog. However, even there we use digital equipment. Specifically, in a ten to one model, we have to shift all tones, all frequencies, up to 10 times their normal value when emitted from the tiny loudspeaker on the stage. These frequencies are "heard" by the tiny microphones in the dummy head, but what gets to our ears has to be translated downward by a factor of 10 so that we can hear them. Modern digital equipment is used to make these translations. All measurements in the finished hall are made with modern microphones, recorders and digital equipment.

Geselowitz: In your earlier interview with us with Jean Abbate you talked about your role in the formation of the Professional Group on Audio in the Institute for Radio Engineering.

Beranek: That is true.

Geselowitz: You also mentioned the American Acoustical Society. Recalling from your interview and other things I have read, there was a great deal of overlap. The radio engineers who were doing broadcast and acoustical kinds of things really felt they wanted a home within the radio engineering community as opposed to in the more physical/physics-oriented Acoustical Society. Now however that Society has evolved to the point where today it is called the IEEE Signal Processing Society. When you talk to them, everything is Fourier transforms and computers. What would you say about your place today and the kind of work you do in those two societies in terms of where one would publish and so forth? They both have strong publication programs.

Beranek: There really are three societies to consider: the Acoustical Society of America, the Audio Engineering Society, and the IEEE Signal Processing Society. Before the Audio Engineering Society was formed, the Professional Group on Audio was established in the IEEE, because the Acoustical Society was not attracting papers from the audio industry. The IEEE seemed the proper place for papers on recording, studios, microphones, loudspeakers and so on, because they are a legitimate concern of radio and television engineering. The Audio Engineering Society was formed at almost the same time and probably because it was small it quickly attracted a lot of followers. Also, it seems that the IEEE appeared formidable to many audio people so that not many audio papers were sent to its publications. However, the IEEE group gradually developed a niche of specialization, as a result of the fact that all audio work involves the analyses of sounds – speech, music and noise. Sound analyses at first made use of octave band, third octave band and narrow band analyzers. As time went on higher mathematical processes became available for analyzing audio signals, the fast Fourier transform, the cepstrum and others. Gradually over the years the audio group name has migrated to the IEEE Signal Processing Society.

Geselowitz: You are saying that the IEEE now is much more concerned with the mathematical and theoretical.

Beranek: Right, but these techniques have practical applications in evaluating audio signals.

Geselowitz: I understand that the Audio Engineering Society is more concerned with the practical. What about the Acoustical Society?

Beranek: The Acoustical Society has not gone into loudspeakers and microphones nor into the analyses of signals. It has been more concerned with the psychology and physiology of sound, with the design of concert halls and opera houses, with architectural acoustics and noise control, underwater and space sound and with the theoretical aspects of sound. I publish papers on room acoustics in the Journal of the Acoustical Society of America.

Geselowitz: You just raised another question, which is the problem of the human ear. Even forgetting the psychological potential of psychoacoustics, just the fact that everybody's ear is different if you measured a bunch of properties of the ear probably each property would be a distribution across the population. I'm guessing that the musicians sitting up on the stage have a better ear than the average audience member. What is the ultimate gauge that you have succeeded? Is it the critics, the musicians or you yourself?

Beranek: I found that the musicians and critics opinions about acoustics in an auditorium are not very different. Both understand music. They can talk about it in detail. The only difference is that one sits in the audience and the other is on the stage. In a hall that is really good, they both agree that it is good. There are some halls where the sound is good on the stage and not good in the audience. Usually if it's not good in the audience those on stage also don't like it.

Geselowitz: Interesting.

Beranek: The general audience does not have that much sophistication, so they come there to enjoy and be bathed by the music. They enjoy the sounds and rhythm and melodies. They don't go in there with the true understanding that one finds among musicians and music critics. My opinion as to what is good acoustics has evolved through the years based in large part from my discussions with music critics and conductors.

Geselowitz: I mentioned before this being the contribution of an art and science. Do you feel that over the years you have developed a critic's ear when you go into a hall?

Beranek: At my age my hearing is not the best so I have to use hearing aids, but up until about 1995 my hearing was quite good. I sat in the audience in a number of halls with conductors, for example, Leonard Bernstein and Erich Leinsdorf, and we discussed what we heard. I found that I was hearing the same things they talked about. I felt that I was understanding what they like and dislike and I came to feel that my judgment was in sync with theirs.

Geselowitz: Great. Thank you for the interview.