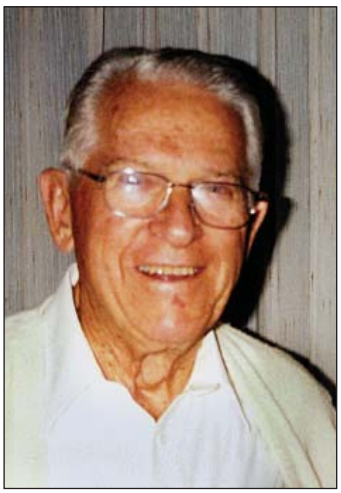
The Squeaky Wheel . . . and Other Serious Things

Laymon N. Miller, Fort Myers, Florida



I grew up in El Paso, TX and went to the the Texas College of Mines and Metallurgy (now UTEP, The University of Texas at El Paso). In those depression years, the tuition was $25 per semester plus books and lab fees. I majored in physics and math, had an outstanding teacher in each of those subjects and graduated in the Summer of 1938. I then went to the University of Texas in Austin and had several more outstanding teachers, one being Dr. Paul Boner, noted acoustician even then. But I wasn't into acoustics; I was in electron and atomic physics, and my Master's Thesis was in radioactivity. Somehow that qualified me to be sent by the faculty to Dr. F. V. 'Ted' Hunt's Navy Lab, the Underwater Sound Lab at Harvard University in October 1941, just two months before Pearl Harbor. I immediately became immersed in underwater sound – learning about generation, transmission and reception – and in the design, construction and testing of transducers (mostly for acoustic homing torpedoes). At the end of WW II, that work was moved to the Ordnance Research Lab at Penn State. I worked there until 1954 when I joined Bolt Beranek and Newman in Cambridge, MA. The rest is history, as they say, and some of that is contained in the accompanying article. I retired from BBN as a Principal Consultant at the end of 1981 and we moved to Florida. At the end of my "Squeaky Wheel" story, if you can persevere, I have added what I believe is a very important P.S.

Laymon Miller is a Member of the Acoustical Society of America (ASA) since 1943 and was elected Fellow in 1956. He is a Member, Institute of Noise Control Engineering (INCE) since 1977 and was board certified in 1993. Laymon was named an Honorary Member, National Council of Acoustical Consultants (NCAC) in 1994. He has been a Contributing Editor to *NCAC Newsletter* from 1996 to the present, Technical Editor at *NOISE Control* magazine, 1960-1961 and a Contributing Editor to *Sound and Vibration* from 1977 to 1998.

I am sure you have heard of it, but we actually saw it – a framed picture in the window of an art gallery. It said boldly:

The wheel
that squeaks the loudest
is the one that gets the grease.
Josh Billings

Now, that might sound like simple homespun philosophy to most people, but not to the guy who has a grease gun in his hand, . . . nor to an acoustician. We went in and bought the framed famous 'slogan.' Later, we made a slide of it, and still later it appeared at one time or another in almost every one of my talks on Noise Control. Well, who was Josh Billings?

That wasn't even his name! Henry Wheeler Shaw (1818-1885) was an American humorist who became famous under the pen name of *Josh Billings*. He was born in Massachusetts, and at age 40 moved to Poughkeepsie, NY, as an auctioneer and real estate dealer. He wrote articles for newspapers but they didn't attract very much attention when written in a serious vein. Then, he tried some of his crackerbox stuff and that was popular. Hence, the "squeaky wheel." There were others but this is his best from my point-of-view. My life in acoustics has come across a few squeaky wheels and lots of other noisy devices.

Enter Stealthy Acoustics

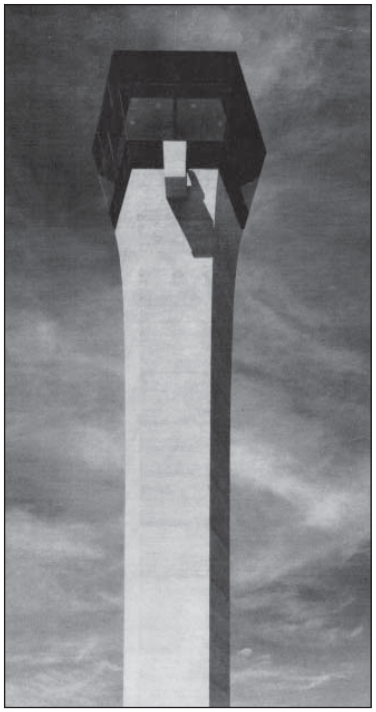
It was my first paying job out of college. I wasn't even trained in acoustics, but Ted Hunt and the Navy didn't seem to care. I joined what was to become the Harvard Underwater Sound Lab (HUSL) on October 10, 1941. As submariners would say, "there's been lots of water over the bridge" since then, but we worked diligently, cooperatively, and competitively with Bell Labs and helped develop the acoustic homing torpedo. There were some historic events in those four years, but most of them should remain unsaid, so we will move on. At the end of World War II, Harvard did not want to continue wartime work in peacetime, so our half of the lab was moved to Penn State where we became the Ordnance Research Lab. I was there until 1954, when I received a very important invitation from Leo L. Beranek to come to BBN for an interview.

Enter Bolt Beranek and Newman

I had known Bob Newman when we were graduate students in Physics at the University of Texas, I had known Leo since 1942 when he was Director of the Electro-Acoustics Lab at Harvard, and we knew Dick Bolt as the liaison representative to HUSL from the NDRC/OSRD office in New York. NDRC and OSRD were wartime agencies that brought together the military needs and the engineering and scientific manpower of our country at that time. So, it was a happy reunion in 1954 for me to see those three noted acousticians at that interview. I came (as employee No. 14) and I stayed 27 years – about the most dynamic time of my life. In addition to Bolt, Beranek, and Newman, just imagine the privilege of working with Ira Dyer, Clay Allen, Bill Cavanaugh, George Kamperman, Ted Schultz, Sam Labate, Warren Blazier, Bob Bruce, Jack Curtis, Jack Purcell, Colin Gordon, Parker Hirtle, Bob Hoover, Eric Wood, Eric Ungar, Ed Kerwin, Karl Kryter, Carl Rosenberg, Istvan Ver, Bill Waters, Francis Wiener, and, while I am name-dropping, how about Walter Rosenblith, 'Lick' Licklider, Ken Stevens, and, yes, Jack Mowry! I left out about a hundred others. One of the best things about working at BBN was that each week we had meetings in which we learned what each other was doing. The sharing of problems and potential solutions made it better for us and our clients. Suppose I name a few of my problems as examples. I will intentionally omit the names of some of the clients and job identifications. Of course, we are all accustomed to normal consulting jobs, so I might mention a few abnormal ones.

A Most Visible Job

The problem with noise control is that if you do your job well, no one knows about it – you don't hear it! You can see this first example, however, every time you go to the airport. It is highly visible. We worked with the architect on noise control for the prototype of the then-new FAA airport control tower, the tall five-sided tower that became the standard. Different sizes and heights allowed it to be customized for different locations. The slanting glass windows gave it a distinctive appearance as well as adequate transmission loss for various external airport sounds (the slanting orientation was an architectural decision, not an acoustical requirement); internal configurations stressed the communication requirements



Prototype F.A.A. airport Control Tower, designed by I. M. Pei Architects. In 1969, Architectural Forum called it " . . . a rare blend of art and function." Acoustical considerations: window design to limit airport noise intrusion into operations area, internal configurations to allow best communication between Control Tower operators and aircraft pilots, noise and vibration control of equipment on floor below.

of each operator with airline personnel, and noise and vibration control measures were applied to the equipment floor immediately below the operations floor. A Control Tower can be a very busy place, but we tried to keep it as quiet as possible from unnecessary noise distractions. The prototype design dates back to the late 1960s; the first time I saw this new design in real life was when it was being built at Chicago's O'Hare Airport. Now, in 2007, some of those original control towers are being replaced by new ones of larger size and taller height to give better coverage of their airport operations and to include more updated equipment. I have a beautiful full-page photo of an early Control Tower of this series from a 1969 magazine; the photo has this note at the bottom: ". . . a rare blend of art and function" – *Architectural Forum*.

A Most Frustrating Job

(Maybe 'THE' most frustrating.) It was a large office building, still in design, and the ductwork and the company's Board Room produced a very serious problem. The metal duct that passed through the shallow 12-inch deep ceiling space directly over the Board Room had to be five feet wide, thirty feet long, and only eight inches high. The air flow paths leading up to that duct were so bad that I knew we would have a turbulent-flow problem; I just wasn't certain how bad a problem, quantitatively. I worried about low-frequency duct-generated noise; and I had a five foot wide by thirty foot long piece of metal ductwork right over the ceiling, ready to become the very best low-frequency loudspeaker (radiator) that anyone could imagine. The consultant can advise, not dictate! I tried to convince my client to make major changes in that layout, but it was too fixed in their design to allow any change. Yes, the duct became a wonderfully efficient low-frequency transducer. It radiated well as bare duct; it could still be heard when it was covered with one inch of dense plaster; I even talked them into a second inch of plaster over the duct. Then, they had to close up the ceiling with dense plaster, instead of a normal acoustic panel ceiling. The final results were acceptable to the occupants who never knew how hard we had worked to reach that condition. But, there was a sense of dissatisfaction among those of us on the job; it was a 'jerry-rig' treatment. With smoother air flow, there would have been no problem at all.

An Aircraft Quieting Job

I received a phone call from the Chief Engineer of Cessna Aircraft Company in Wichita, KS. He had learned of BBN's work on aircraft quieting and he said they had a job for us: their Model 310 Twin-engine Business Plane. The objective was to reduce the internal cabin noise as much as possible. There were five seats in the plane, two in front for pilot and assistant or passenger and three in back for passengers. There was also a large luggage space behind the rear seats. I went to Wichita and designed a measurement program with their Chief Engineer and Chief Test Pilot. Cessna built some

Twin-engine Cessna Model 310. I conducted a two-week noise measurement program at the Cessna plant in Wichita, KS. The various noise reduction steps were introduced over the next five years of the production model. However, we found one serious noise leak in a gasketed door, and that was corrected in the assembly line the very next morning.

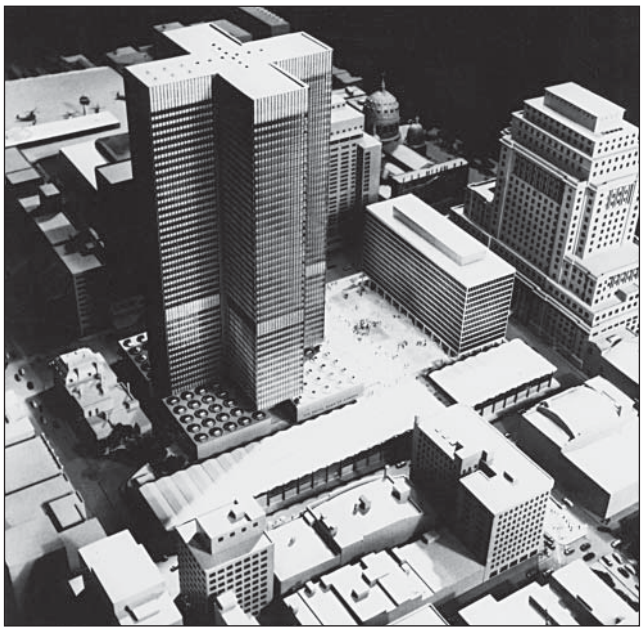
heavy double-wall blankets that would fit over each wall panel and window in the plane, with provision for attaching them and removing and replacing them one at a time in flight. My intention was to build a high TL construction all around the cabin and then to open one section at a time and see how much noise entered the cabin through that opened section. With such a methodical approach, we could determine exactly how much noise was entering through each of the various surfaces and could then treat those surfaces accordingly. I even wanted us to run on one engine at a time during portions of these tests. The Pilot agreed to all this. He was even willing for us to fly 'blind' on an instrument flight plan with all surfaces completely covered for short periods at a time. The Wichita area was full of aircraft manufacturers and their planes were in the air all around. I figured if the Pilot was willing, I was willing. Of course, FAA Air Traffic Control provided safe separation during these tests. With one particular test, we were also able to separate propeller noise and engine exhaust noise.

I was in Wichita for a full two weeks and I received all the cooperation that I wanted. From the test results, I could determine just what kind of lining treatment should be applied to all the wall panels, and I recommended improvements in gaskets for the doors and increased thickness for the side windows. An easy finding was that the small door in the fuselage that opened into the baggage compartment (behind the back seats) was a serious noise leak. I told them about that one evening, and the next day a corrected design was in production. My thought at the time, after working for 13 years on acoustic torpedoes, was: in research work, we measured progress in years; in consulting, we sometimes measure progress in days, or even hours!

When we finished the complete program, they told me that they couldn't do all of this in one year. Instead, they would incorporate a few changes each year over the next four or five years. Sure enough, as I followed their advertisements in one of the aviation magazines, I saw evidences of added improvements in sound reduction for each new model year.

That Crazy Guy – Talking to the Floor

You must realize that in "days of yore" in acoustics we did not always have some of the compact, portable, multi-channel, multi-functional, self-contained equipment that are available these days. In 1959, I was making some vibration measurements that were involved in the design of a new building to be located over an array of underground railroad tracks coming into the central station for that city. While I was making the railroad vibration measurements, I noticed that as people were walking along the walkway, coming from the railroad platforms, I could distinguish vibration signals caused by their walking. With still more careful listening to the signals, I realized that I could detect some muffled conversations



Architect's model of the "Cruciform Building" of Place Villa Marie in downtown Montreal, later to become the Royal Bank of Canada Building. Acoustical considerations: lower floors of this complex were protected from train-induced vibration due to the underground railroad station, HVAC noise and vibration control for the entire building, and special considerations for the offices and board room on the top occupied floor. This was the job where Laymon Miller was found "talking to the concrete floor."

of the people talking. That gave me an idea: I talked fairly loudly to the concrete floor where I was measuring, and lo and behold, I could recognize my own voice quite clearly. I was actually setting the floor into minute amounts of vibration just by talking to it, and I could then hear the signal that was obtained by my vibration pickup. I did have to ignore the people who would pass by and wonder about that crazy fellow, just sitting there, talking to the concrete floor.

In those days, we had a portable, one-channel, battery-operated magnetic tape recorder, and I was indeed fortunate to have one on this job. I had one cable connected to the accelerometer setup and another cable for my microphone for announcing the conditions. Each signal required a different attenuator setting on the amplifier. Join me for one or two recordings . . . There are 16 tracks into this station and it is the morning commuter rush-hour. Quick – I hear a train coming; I am ready for it – the accelerometer cable is already connected, the attenuator is at the correct setting and I start the recorder. Then, I try to determine from a distance the track number for that arriving train. Immediately after the train stops, I disconnect the accelerometer cable and hook up the microphone cable, change the attenuator setting, and announce the conditions (time, track number, attenuator setting, and anything else that seems to be significant to the data). I hear another train coming, so I quickly reconnect the accelerometer cable and change the attenuator setting . . . and I record another train arrival after which I reconnect the microphone cable, change the attenuator setting again and announce the conditions. Then . . . here comes another train. Quick, get ready. So, you see, it was a very neat 'discovery' to learn that I could just talk to the concrete floor, and the accelerometer could record my announcement data. [Of course, you are going to think that the accelerometer was just an insensitive microphone, and that's why I had to talk loudly to the floor. You are partially right, but it took the concrete floor to magnify my voice. If I picked up the accelerometer off the floor and talked to it alone, my signal was about 30-40 decibels lower. It was not acting like a microphone, it really was acting like an accelerometer.]

Many times later, I used that 'discovery' in my work. Often times, when recording vibration signals for a particular problem and I have wanted to announce the details of that event, I would merely talk loudly at the device that I was studying and I had my own announcement right there waiting for me when I got back to analyze the data. It was a great saving in time and it assured better accuracy of data because I didn't have to jump back and forth from one channel to another, where I might make a recording mistake as I flipped from one attenuator setting to another for the two kinds of signals. And for that first 1959 job, I was busy enough trying to "keep track" of trains coming and going at the commuter hours on those 16 different tracks.

One year, in one of our Noise Courses, I placed the accelerometer on the underside of the demonstration table in front of me. I talked at normal voice level to the class and then played back to the class the amplified vibration signal of the table surface; my voice was easily identified. One of the men commented: "Just wait 'til I go home and tell my wife that when she talks, she shakes the building."

My First Attempt at Being an "Expert Witness"

I sleep poorly in the first place. Just imagine the nights before I was to appear in my first lawsuit as an "expert witness." It involved a highway extension through a residential area, requiring tremendous amounts of earth moving to build up the roadway. A temporary railroad track had been constructed to bring in 100-carloads of earth, and a coal car shaker was being used to unload the gondola cars one at a time over an open trestle. This was taking place just beyond the back yards of a whole street of residences. Coal car shakers are notoriously noisy as their heavy metal weights are bounced up and down on top of the sides of the gondola to free the earth so that it slides through the passages when the bottom doorways are opened. I don't remember the exact details, but let's suppose that it took about five minutes of shaking, then a pause of about five minutes while the next car was moved into place, then the shaking began again, and so on, all day long. The neighbors knew that they couldn't stop the highway construction and they were not even seeking monetary compensation. They just wanted the noise to not start at 7:00 a.m., run until 6:00 p.m. and continue even on Saturday. Some of these details may not be entirely correct but they are close.

For the courtroom appearance, I planned to playback some taped recordings of the shaker noise. I had talked this over with the attorney for the neighborhood group. You might normally call me an "expert witness;" but in this case, I was much too immature in acoustics as well as legal proceedings to deserve that title. Yet, on one particular morning of my life, I drove up to the courthouse, unloaded my playback equipment (tape recorder, amplifier, two loudspeakers, sound calibration equipment, etc.) and took it into the building. Expecting to meet the lawyer, I then set up the equipment early before the proceedings were to begin. That's when the problems began. Somehow, in all the scheduling beforehand, they had not set aside a courtroom for this case. So, the building custodian was instructed to take one of the storage rooms and convert it quickly into a courtroom. The back of this room was loaded with stacks of chairs. A folding table was brought in and placed at the front of the room. That was where the judge was to reign. Some of those stacked chairs at the rear of the room were brought up in front to make two rows for seating of the lawyers and witnesses and possible interested neighbors. There was no room for tables for the lawyers representing the two sides of the case. They just sat there in the front row of chairs, with their papers on their laps and in an empty chair beside them. There was no judge for this case. Hurriedly, someone found an available qualified lawyer and declared him to be 'Master' of these proceedings so he could serve in the capacity of a judge. While a maid was dusting off the chairs and the judge's table, I was setting up my equipment. The "witness stand" was an old rocking chair set beside the judge's table. There was to be no jury. The judge would make the decision. The trial began about two hours late.

The two lawyers presented their openings. As I recall, I was the only witness for the neighbors, and noise was the whole issue. Ultimately, I was called to take the rocking chair. Our side's lawyer interviewed me to establish my credentials. It became obvious quite early, that our lawyer was as much of a neophyte as I was. Often, the judge would interrupt the lawyer and ask him to rephrase the question, and often the judge (the 'Master,' that is), in desperation, asked me the question himself. Mixed within all this, the

opposing lawyer would often offer his objections. Finally, it came time to play the recorded sounds. I had calibrated the system during those opening hours and I was planning to play the sound levels in the courtroom at the judge's table to be equal to those that I had obtained along the neighbors' property line adjoining the unloading operations. Actually, the unloading operation bothered the neighbors residing over the length of a whole city block, and I had measured at several positions. I explained to the court that indoor reverberation conditions were not the same as outdoor free fields but that I was producing as nearly as possible the sounds levels in the courtroom that the neighbors were receiving in their back yards and houses.

When I played the tapes, I was watching the two loudspeakers that I was using. Some people jumped when the sound came on. The cloth in front of the speakers was bouncing in and out in front of the speaker cones with total amplitudes of about one-half inch. This fluttering of the speaker cloth was obvious to anyone looking at the loudspeakers. That was as impressive as the raucous sound of those shakers. We played the noise sample for about five minutes just to somewhat give the impression of duration. That was the length of time for one car unloading. An 8- to 10-hour demonstration would have been even more impressive. That's what the neighbors were getting every day.

A few weeks later, I received a copy of the newspaper that told of the verdict. The judge ruled that the highway must go through, but that the hours for shaking should be limited to something like 8:00 a.m. to 5:00 p.m. and none on Saturday. Now, a few decades later, the highway is in use, making still another kind of noise for those neighbors. Maybe they have forgotten the coal car shakers, but I still remember very vividly that first courtroom experience.

My Most Prestigious-Sounding Job

A short time after President Lyndon Johnson inherited Air Force One, following the assassination of President John F. Kennedy, he seemed to notice that it was noisier than he had remembered. So, the Air Force General in charge of the President's fleet requested that some quieting work be done. In due time, I was scheduled for a four-hour flight on Air Force One to make the necessary noise and vibration measurements.

On an early morning in late 1964, I flew to Washington's National Airport, loaded with measurement equipment. My flight from Boston was on an Eastern Airlines Shuttle in a turboprop Lockheed Electra; I even measured the noise level at my seat position during that flight. I took a taxi to Andrews Air Force Base in Camp Springs, MD, southeast of downtown Washington D.C. and just outside of I-95. When I arrived at the field, the engines were running and I had to rush to get all my stuff on board. It was a beautiful plane, painted blue and white with a large "United States of America" painted along almost its entire fuselage length, and a gold seal of the President of the United States near the entrance door on each side of the plane.

While the plane was taxiing and taking off, I was getting my equipment unpacked and set up. I planned a thorough series of noise and vibration measurements all around the President's office as well as in the sleeping quarters. In the bedroom, I saw the famous red telephone used for real emergencies. Incidentally, there were three 707s in the President's Fleet – one for the President and special guests (although there were no sleeping quarters for anyone else). This one also included a complete galley. A second 707 was for visitors, guests, and the media. The third one was to hold all the necessary emergency communication equipment to serve as a second White House in case of a national emergency. In President Johnson's 707 office, there was a large kidney-shaped conference table. The President's chair was at the center of the semi-circle, and there were five or six bolted-down chairs all around the outer

In 2002, we were in Seattle and included a visit to the Boeing Museum of Flight. At the entrance to the Museum was this 707 – a retired "Air Force One." The internal office layout was different, so it might not have been the one that I worked on in 1964. On the other hand, maybe the internal office arrangement was changed for a later President. Another retired "Air Force One," also a Boeing 707, is now resting on the grounds of the Ronald Reagan Presidential Library in Simi Valley, CA.

edge of the large table. In talking with some of the crew, I learned that President Kennedy had much more intimate arrangements for people-to-people conversations. There were several small tables scattered around the office so that two people could talk to each other across a table at a short distance of about 24 inches, head to head. The President, or anyone else, could circulate around the room and sit down for a discussion at any one of those small tables. With the large conference table that President Johnson used, the head-to-head distance for conversations was about 4 to 5 feet. The new noise problem became obvious – in the presence of the same amount of jet engine noise, it became necessary to talk louder to cover the greater distance between speaker and listeners. President Johnson had interpreted this as an increase in the cabin sound level, since he had to talk noticeably louder. I learned that there had been no change of engines and that there seemed no other logical explanation for the increased noise levels that President Johnson noted.

For about three of those four hours that had been allotted to my work, I acquired a considerable amount of noise and vibration data in and around various parts of the rear of the cabin. From the vibration levels of various structural components and surfaces (including windows), it was later possible to confirm the sound levels that had been measured. After I had completed my work, the pilots and crew made several practice touch-and-go landings at Dulles Airport; then we returned to Andrews Air Force Base and I left to fly home. My return to Boston was on a Northeast Airlines DC-6B; I measured the sound levels at my seat position in that commercial airliner on the way home. In those days, the Lockheed Electra and the Douglas DC-6B were just about the noisiest of all propeller passenger planes; yet, the President's office was noisier than both of them in the speech frequency region. It is generally known that the maximum noise of a jet engine is radiated at an angle of about 45 degrees from its rear axis. So, with four wing-mounted jet engines on the 707, the President's office was located right in that 45-degree noisy zone behind and off to the side of the engines. The office could not have been located in a noisier region!

From our Speech Interference Level table, we were able to arrive at a target of about 8 dB noise reduction in the speech frequency region to restore the original speech intelligibility conditions. In the next few weeks, I completed my report and recommended a beefed-up wall lining inside the cabin, including a vibration isolation scheme for supporting the cabin lining from the ribs and struts of the aircraft structure. I felt comfortable with these recommendations for they had been time-tested on some of our earlier jobs. Incidentally, one of my recommendations was to reconsider the use of the smaller tables, but I knew that idea would not 'fly.'

In due time, a meeting was held in Washington to discuss the results and recommendations of my work and to proceed with their implementation. Would you like to know the results of that meeting and the follow-up work on the plane itself? So would I! I was not permitted to attend and discuss the final design – I did not have a high enough Security Classification. I had worked on 'Secret'

projects for the U.S. Navy for 13 years and had four hours flying time in Air Force One and was the author of the report, but when it came time to discuss the results, 'Secret' was not good enough. When it was written, my report had no Security Classification at all, but the meeting was declared to be "Top Secret." I learned later from my client that the meeting went okay but that I should have been there to assist in some of the compromise decisions that had to be made. I never learned what the changes were, but if I had been at the meeting I might have been able to offer better acoustic compromises than those that were finally selected (whatever they were). Nevertheless, my work was approved and I received different noise-quieting jobs on the other two 707s of the President's Fleet. That was in 1964-65.

New York World's Fair, 1964-65

I had three jobs for that World's Fair, but I only want to mention one of them here. The year before the World's Fair opened, the New York Port Authority had its own Transportation Building built at the World's Fair site. It had been designed by their own Architectural Department, and it featured a large "T" for Transportation as seen from any of the four sides of the building. The rooftop was a heliport for bringing in VIP visitors to the World's Fair grounds. The top floor under the roof had a large Reception area for VIP occasions, and it included a few large and impressive Conference Rooms. Beneath that was a very fine restaurant. Of course, all of those places had to be protected against the whack-whack-whack of helicopter operations and any impact of helicopter landings. Forty years later, I do not remember the design details for those treatments, but they were successful.

It's a Crazy Idea, But it's Cheaper

So They Added Sand Bags. A new office building was completed several years ago in one of our larger cities. It was fairly common practice to locate all of the top executive offices on the top occupied floor. Typically, on the floor immediately above them would be located much, if not all, of the mechanical and electrical equipment that served the entire building. This could include cooling towers, air conditioning compressors, motors, pumps, and fans – lots of potential noise and vibration sources. I had not worked previously on this particular building, and did not know the architect or mechanical engineer for the building. One day, I got a phone call shortly after the building was completed and the offices occupied: "This Executive's Office is noisy."

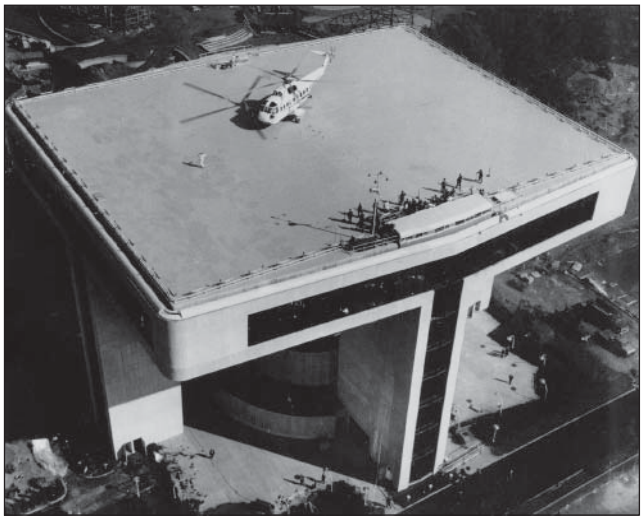
It was a large, beautiful office, but it had some horrendous problems. The executive was out of town on the day of my visit. These were my first impressions:

- The door in its frame hummed with feelable vibration
- The windows rattled slightly but continuously
- An air diffuser in the ceiling was vibrating visibly
- The Venetian blinds chattered as they vibrated against the window frames.

I sat in the office chair; there was feelable vibration. A glass of water on the desk had a pattern of shimmering vibration on its surface. The architect had referred to all this as 'noise.' I called it 'vibration.' With all these signs of vibration, there was hardly any need to think about noise, but that was present, too.

I asked to go to the Mechanical Equipment Room upstairs. The Fan Room was immediately over this office. A 75-HP supply fan was almost directly over the desk, and a 25-HP return fan was over a spot at the far end of the office. Those were big fans! Instead of being properly mounted on large vibration isolation springs, the steel frames carrying the fans and their drive motors were bolted firmly and securely directly to the concrete floor slab. There was no vibration isolation – the very worst thing that could be done – no attempt to do even the most elemental job of vibration isolation. No wonder the executive was shaking.

Each fan was inside its own fan plenum (housing) with appropriate duct connections. I made some noise and vibration measurements to document the job. Back at home, I studied the problem and submitted my letter report to the client. Of course, I recommended a high-quality well-proven vibration isolation treatment for the fans. There were other vibration problems in the building as well. I assumed that my report was being followed, as I heard nothing more from the job.



The Transportation Building of the Port of New York Authority at the New York World's Fair, 1964-65, designed by the Port Authority Architectural Department. Acoustical considerations: noise and vibration isolation of the rooftop helicopter landing surface from the reception area, conference rooms, and restaurant on two floors below. The prominent 'T' for Transportation symbol was seen at all four sides of the building.

About three years later, I had a job with some people in that same building, but on an entirely different problem. They didn't know who I was when they asked me to work on their job, although they had been in that building from the time that it was first built. By way of opening the conversation at our first morning's meeting, I mentioned that I had been involved with the office vibration problem. They started laughing. I wondered: What happened? They went on to say that someone was convinced that the vibration was due to the resonance frequency of the floor slab up on the Mechanical floor, and it was decided to change that resonance frequency by adding weights to the floor. The way they added weights was to place two or three layers of sand bags on the floor inside the Fan Room, right over the office in question.

Have you been inside the plenum of a large fan while it is running? There is a lot of wind! A 75-HP fan is so powerful that it is like a hurricane inside the Fan Room, it can pull papers out of your hand or your shirt pocket if you are not careful, it will mess up your hair, it can almost pull your coat and necktie into the fan inlet, it is basically a very hazardous place to be. You don't dare stand too close to the open fan inlet. . . . They put sand bags inside that room?!? Can you imagine a floor loaded with sand bags in that sort of setting?

The new client whom I was visiting said that for the past three years, the first thing they did each morning was to brush the sand off their desks and sweep the floor. Sand was pulled out of the sand bags by the terrific wind force and was distributed all over the building. The fan and drive motor bearings were wearing out repeatedly and sand was found in all parts of the total duct system. Yes, it is true that a concrete floor slab can have a resonance frequency, but that was no where near the solution to that problem. They finally decided to put the fans on proper mounts – several tens of thousands of dollars later. Years earlier, I had offered a perfectly normal and acceptable solution to the vibration problem, and it was ignored. The client thought he had a cheaper solution.

A Client with a Good Sense of Humor

There was a manufacturing company located about one-fourth mile from some nearby residents. The company had a good reputation for its specialty products, so they were kept busy and often had nighttime work. In the summertime, it got hot inside the plant and they opened a large roll-up door for ventilation. Plant noise escaped through the big open doorway, and the neighbors complained about the noise. I was called to visit the plant and sit in on the courtroom proceedings. My client was the company president and he didn't want me to testify; he just wanted me to

be present to let his attorney know if the opposition was making any unreasonable or outrageous claims.

I flew in the next afternoon and was met at the airport by my client's attorney. Since he had the car, I asked if he would take me to the plant in the evening so that we could observe the noise situation. At first, he said that he thought he should not be there because it might influence his attitude. I told him that we should both go together to see and hear the problem, because if he wanted my opinions in the courtroom, we should both be fairly acquainted with the problem firsthand, and he should know what I am talking about. Reluctantly, he agreed. First, I asked if it was too late to stop the law suit and solve the noise problem. Can you imagine a lawyer wanting to stop a law suit? We were in the courtroom the next morning.

We listened to the testimony of the opposing group, and I passed a few notes to the lawyer and the company president. Nothing very dramatic occurred, and I was not called to testify during the three days of the trial. At the end of the trial, the judge found in favor of the company. He believed that the company was of value to the community, that its noise was not a disturbing influence, and that the plant did not contribute to a lowering of the monetary value of the real estate in that area.

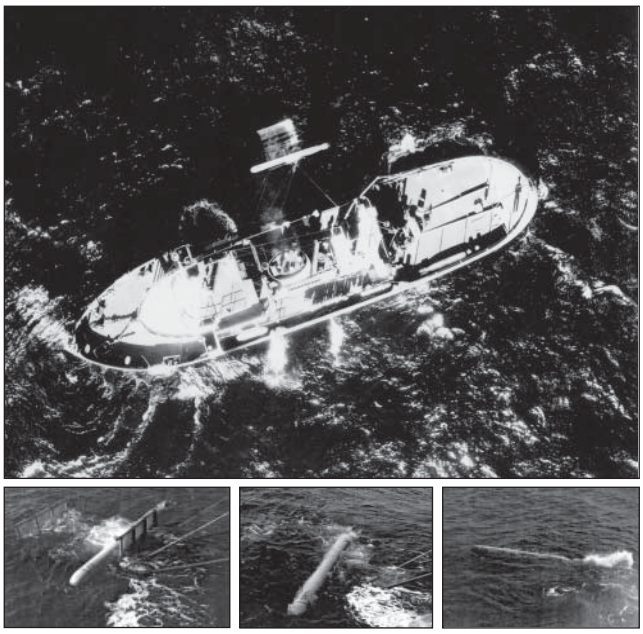
After the judge gave his decision, the company president took me to dinner that night and asked me to work on the noise problem. He said he wanted to be a good neighbor; he just did not want the judge to tell him what to do or how to do it or how much to do. That night, he treated me to a "Golden Cadillac." it was an after-dinner liqueur made of equal parts of cream and Galeano (that is the golden looking wine or liqueur that comes in a tall slender bottle), stirred together over crushed ice. Acoustics has its fringe benefits.

I mention this case because I have been in several other legal situations where the manufacturer or the airport or the highway or the power plant wanted to be a good neighbor. They just feared the unknown if a judge should be the one to dictate the solution. In this regard, I believe that I have done more useful quieting for community groups when I was hired by the company making the noise than if I had been working for the opposing community group itself. When the problem is justified and the company is willing, a good job will be done – and at their expense. That is a win-win situation!

Let me mention something else. The company president and I became good friends on an easygoing basis. He picked me up each morning at the hotel and we had breakfast together. One morning, he said that he had seen that the BBN stock market price had gone up overnight. He added, "I guess those Wall Street fellows have learned what you are charging me just for being here."

Is Acoustics a Hazardous Occupation?

I had some close calls back in the days when I was running a research torpedo at the Ordnance Research Lab at Penn State. One in particular stands out in my memory. I won't detail all the steps involved, but it was my job to manually start the switch that was to start a sequence of programmed events inside the torpedo, concluding with the actual firing of the torpedo itself. There was a 120-second sequence. We lowered the torpedo (in a conveyor-type 'basket') over the side of the boat and, as usual, I went with it into the water. As soon as I started the switch, the Navy fellows were supposed to pull some lines that would release the torpedo and the boat would slowly back away and leave the torpedo free to start of its own accord. On this particular occasion, something went wrong and the torpedo was released, but the stern lines were caught up by the steering rudders and the props. Two lines were fouled under the floating torpedo and two lines were on top of the torpedo, snared by the rudders and prop blades. About 30-40 seconds would have elapsed at this point in any normal operation, giving us about 80-90 seconds remaining to slowly back out of the way. But, with the snared lines and the resulting confusion and the shouting from the deck, who knew what time it was? I was frantically holding onto the side of the basket with one hand and trying to reach out and pull away the tangled lines with the other hand. I called out to someone on deck; "How much time is left?" No one knew; it normally didn't happen this way and no one was



In the first aerial photo of this sequence, my "Acoustics Research Torpedo" is in the 'basket' over the side of the Navy ship shown at top. In practice on a good day, the basket is lowered into the water until the torpedo just floats. Holding lines around the torpedo are then released and pulled on board. The basket is lowered still deeper until the torpedo floats completely free. Then, the ship backs away slowly. Several seconds later, the torpedo fires and makes its run. That's on a "good day." It didn't always work that way. In the event described in the text, I had ridden the basket into the water, and after I pulled the 'start' switch, the lines got fouled on the props and rudders. The sequence of photographs shows the improved procedure that we developed later (where I did not ride the basket into the water). We had Blimp coverage to help find the torpedo at the end of the run. Nothing worked as simply as the photos would imply. For example, just consider a rough sea.

supposed to be checking on the exact time. With a lot of entangled heavy lines while the torpedo bounced up and down on the wavy sea surface, it was not easy to disengage the lines with one hand, especially around those four rudders and the blades of two large propellers. I had no idea how much time remained; yet, there I was within inches of those prop blades which could start at any instant. Finally, I freed the lines and gave the hand signal for the Skipper to start the back-down. Within seconds, the torpedo started, barely outside the basket. That was a close one! There were others, too, but not quite that sensational.

Some of my innocent-sounding BBN jobs also carried a little bit of risk. One time I was making some nighttime ambient noise measurements for a client in the nearby community. I was standing under a street light so that I could read my instruments better. Across the street, I heard a front door open and shut noisily. Next, I heard the fellow on the front porch cock his gun, also intentionally noisily. I completed my measurements quickly and quietly at that site and was soon on my way. I stopped by the police department and told them of my good intentions.

On another occasion, I was involved in the acoustics of a railroad crossing accident between an auto and a passenger train. Could the auto driver hear the train whistle? In our preparation for the case, we planned to run several simulated approaches of a similar-model automobile up to the railroad track, using the same train make-up, the same engine crew, and the same location and geometry as had occurred at the time of the accident. I was to be in the automobile, driven by a helper, approaching the track and recording the sounds, while the train was barreling down on that particular intersection out in the open countryside with unlimited visibility. We were to make several such runs, under different conditions: car windows up, car windows down, air-conditioner on, air-conditioner off, car radio on, car radio off. Meanwhile, the train engineer would blast the engine's horn for each approach, just as was done at the time of the accident. We would be checking on the audibility of the engine's warning horn in the midst of those auto sounds, as heard inside the car.

On the very first simulated approach, to be made at realistic

Noise and vibration measurements for a passenger cabin Noise reduction program on the Piasecki Military H-21 helicopter. Below from the left: Leo Beranek, Harry Sternfeld of Piasecki, Laymon Miller and another Piasecki engineer; above, the Piasecki pilot.

A short time after our noise measurement program was completed, Piasecki became Vertol, and the military H-21 was modified to become the Vertol Commercial Model 44 Helicopter (shown here), which received our recommended acoustic treatments. With an enclosure around the overhead drive shaft and some well-designed interior lining for the cabin walls, we achieved a noise reduction of about 5 decibels in the low frequency region (where the vibration was dominant) and 22 to 26 decibels in the speech frequency octave bands.

auto speed right up to the track, it had just begun to rain and the street was wet. My driver was doing his job – in fact, a little bit too well, I thought at that instant. He had us going at full speed right for the intersection, and the train was coming fast. My recorder was 'ON,' and the street was wet. And, all of a sudden, I didn't think we could stop in time. Although the geometry was perfect, that approach was ruined because all you could hear in the later playback of the recording was my shouting "Stop, Stop, Stop!" At that instant, I thought that our driver misunderstood our plan and was really going to let us crash into the engine.

In 1957, Leo Beranek and I were involved in a quieting program for the conversion of a Piasecki twin-rotor military helicopter to a commercial version. For some technical reason that I cannot recall, our aircraft was termed "Experimental" which meant that we had to wear parachutes in case of any unexpected developments. We have a photograph to prove it. And, we had to sign a waiver so that we could not blame our client if we had an accident!

I was flying to another job one time. It was a very windy, blustery day and we were approaching for a landing on a mountain-top airport – in a regularly scheduled airliner. It was to be a "white knuckle" landing. On our first attempt, we hit the runway hard and bounced back up about 15-20 feet into the air. During the same approach, the flight crew tried again and bounced off. We were quickly running out of runway! The pilots added full power and we started a missed approach. The landing gear was retracted and I heard the wheel well doors close with a 'clunk.' We climbed out and went around for a second approach. As we were coming in for our next landing attempt, I kept waiting to hear the wheel well doors open and the landing gear to be extended. We kept getting closer to the ground. I was certain that the crew had forgotten to lower the landing gear with all the troubles they had been experiencing in their first approach. I was fully prepared for a crash landing. Closer, closer, still no sound of landing gear extension. But we touched down bumpily and we were safely on the ground. Obviously, I misinterpreted some of those earlier sounds.

Elsewhere in this special Anniversary Issue of *Sound and Vibration*, Leo Beranek has described the role of Boeing, the New York Port Authority, and BBN in the coming of the commercial jet age. In an early step of that developing story, Leo and I went to Paris to measure one of the first twin-engine Caravelles produced by Sud Aviation. After our measurements were completed, we were invited to have a ride in the Caravelle. Of course, we were delighted to accept. The plane was already full of invited Air France people from Orly Airport and it had thousands of pounds of weights strapped to the floor to simulate full gross weight for takeoffs. Leo and I and our two Sud Aviation engineers were in our seats – about mid-cabin. At the last minute, three TWA pilots were invited on board and were taken to the cockpit. I brought along my noise measuring gear for this historic flight – Leo's and my first in a commercial jet. As I was getting set up and turning on my equipment, the engines were advanced to takeoff power and we started down the runway. My Sud Aviation engineer said something to me but I was too busy to listen. Instead, I heard one of the two engines spool down and I assumed that we were going to abort the takeoff. At that point, we were airborne on one engine. The flight crew was demonstrating a single-engine takeoff to the visiting TWA pilots – FAA rules require that a multi-engine aircraft must be able to take off with one engine out. What a way to start our first jet ride!

At cruising altitude with both engines powered up this time, I handed my microphone to Leo and asked him to comment. At this historic moment for both of us, he said "We're flying; . . . it's like a bird, . . . no vibration!" We were more accustomed to the vibration caused by propellers and piston engines. As an interesting side note, the original 'caravels' were the little sailing vessels used by Christopher Columbus; his Santa Maria, Pinta, and Nina were caravels. This modern flying French Caravelle was also exploring new territory.

When Bob Hoover and I were going to England to measure the noise of the de Havilland Comet 4, we flew from New York to London one night in a conventional four-engine propeller-driven

Twin-engine "Caravelle" jet airliner produced by Sud Aviation of France. This was the first of the commercial jets to meet the noise requirements of the Port of New York Authority. Takeoffs and landings of the Caravelle were measured by Leo Beranek and Laymon Miller at Orly Airport, Paris, in 1957.

airliner. Somewhere out over the Atlantic, one of the engines didn't sound 'normal.' I was awake for the rest of the Atlantic crossing. The next morning, I told my client friend 'Pat' Pattarini, from the New York Port Authority, who was accompanying us on this trip, of my concern with the 'malfunctioning' engine. He said: "Oh, the pilot was just finding the right fuel mixture." I wish one of the pilots had told us that.

I was also with 'Pat' Pattarini when several of us went together from New York to Seattle to measure the Boeing 707 (mentioned in Leo Beranek's article). We took a regularly scheduled flight to Seattle, via Chicago's Midway Airport (this was before Chicago's O'Hare Airport). Our plane was one of the remaining Boeing Stratocruisers still in service. On the takeoff from Midway, Pattarini and I were sitting together and we became tensely aware that we were using up a lot of runway and still not airborne. Finally, it seemed to us, we hit a bump as we crossed over one of the airport taxiways, and that bump gave us just enough lift to get off the ground and clear the fence surrounding the airport grounds. We were awfully close to the tops of some chimneys of residences just outside the airport perimeter. Okay, so Acoustics is a perfectly normal occupation, and all those situations were just run-of-the-mill. At least, they gave me a chance to tell of a few other acoustic consulting experiences.

While in Seattle on that last trip mentioned above, we made noise measurements on a production Boeing 707 that was to be delivered to Pan American Airways. In addition to takeoff and landing measurements, which are mentioned in Leo Beranek's article on the New York Port Authority, we made ground run-up measurements in order to calculate the sound power level of the total aircraft at takeoff power.

My "Fifteen Minutes of Fame" Job

OSHA (Occupational Safety and Health Administration) came into existence on January 1, 1970. Prior to that, there was the Walsh-Healey Public Contracts Act that was an earlier attempt by the U.S. Government to begin to recognize the problem of noise in industry. Although OSHA covered many aspects of employee health and

Some of the Noise Measurement Equipment taken to Paris for the Caravelle study. This photo is offered primarily to show the bulky equipment used in those days (1957). The Ampex magnetic tape recorders worked only on 60-Hz AC (we called it 60-cycle in those days), and we had to take two sets of auto storage batteries and converters to produce power while we recorded out in the middle of the corn fields. In the photo, from the left: Laymon Miller, Leo Beranek, and the two Sud Aviation engineers who were our assistants while we were there.

At Boeing Field in Seattle in 1958. Two vehicles with sound recording equipment circle the new production-model Boeing 707 with its engines at takeoff power, to obtain data for determining the sound power level of the aircraft. Note the microphone at the end of a boom out in front of each car so as to minimize any distortion of the sound field.

safety, its noise regulations were the ones that impacted industry the most and the quickest. Of course, there was a rush throughout industry to measure their plant noise levels and to begin to apply noise control treatments aimed at meeting the OSHA levels.

One of the immediate objectives of the Ford Motor Company was to get someone to participate in their opening kickoff campaign to introduce their company-wide intention to abide by the OSHA noise regulations. I was selected to be one of three people for the meeting to help them get it started. One speaker was to be the noted audiologist, Dr. Joseph Sataloff from Philadelphia; his talk would emphasize the importance of reduced factory noise levels to preserve the hearing of the workers. Another speaker was Jack Radcliffe, the Ford Safety Director; his talk was to impress upon the Ford officers that the Safety Department intended to try to meet the new noise regulations. I was the BBN speaker to represent the 'know-how' for achieving noise control. They allowed us exactly 12 minutes to give each of our talks, and we even had to go to Dearborn to the main Ford offices to have a dress rehearsal about two weeks before the actual meeting. At the rehearsal, I gave my 12-minute talk as planned.

I must now interrupt this story to point out that it was just a few years earlier that BBN had measured the noise of a typical Ford and a typical Rolls Royce on various road surfaces, and the Ford came out a slight bit quieter than the Rolls Royce. This fact was a feature of their full-page newspaper advertising for a whole year, but I was

pretty sure that these Ford officers would not have remembered that it was BBN who had conducted those noise tests on their Ford and the Rolls Royce. Okay, now comes the special kickoff presentation. Twenty-six Vice-presidents of Ford Motor Company, from various plant operations in both the U.S. and Canada, were assembled at this long conference room table. Dr. Sataloff talked first to tell how important it was to meet the noise levels in order to conserve the hearing of Ford plant employees. I spoke second. I started by recalling that BBN had been involved in those earlier Ford vs. Rolls Royce measurements. That took three introductory minutes, which was not in the earlier rehearsed talk. Then, I gave my prepared 12-minute talk. I figured the 15 minutes were well spent. I was not stopped. Jack Radcliffe, the Ford Safety Director, spoke last. So, I can claim that I have had my "15 minutes of fame" speaking to 26 Ford Vice-presidents all at one sitting. Later, I was asked to give a one-hour video talk that was circulated to all the Ford plants, and still later (1978), I was asked to prepare a four-day noise course for a group of Ford Safety and Production Engineers at the Dearborn Inn. For many years, we still had Ford engineers attend our regular noise courses. They would frequently say that they had seen and heard that one-hour video.

In order to provide a very personal and practical view of noise control in their four-day course, I was allowed a two- or three-day trip well in advance of the course, to visit several Ford plants in the Detroit area and to select examples of high noise levels and noisy operations that could benefit from suggested noise control treatments. I even had magnetic tape recordings with photographs to illustrate certain noisy situations and possible treatments. It was an excellent course and we received lots of favorable comments. And the prepared course gave them some actual designed applications for many of their own plant operations, as well as showed them many practical approaches to general noise control.

Sabbatical, Airstream, and the Start of Something Big

In 1964, Francis Wiener, Preston Smith, and I were elected to the position of Principles at BBN. We were the first three to achieve those positions; Francis became Principle Scientist, Preston became Principle Physicist, and I became Principle Consultant. Of the three of us, I was much more involved than the other two in actual consulting on a day-to-day, job-to-job basis. It was probably Leo Beranek, Dick Bolt, and Sam Labate who dreamed up the idea of Principles. They told us that they wanted to recognize our work in the technical field somewhat as a vice-president is recognized for work and leadership in an administrative way. The title carried with it a six-months' sabbatical every five years (with full pay). We were told that we could do anything that we wanted in that six months' period as long as it was not competing with BBN's field of activity. In those days, our consulting rates might have been considered high for some companies, so we probably did not get a lot of business from those who felt that they could not afford us and our expertise. So, four to five years later, as 1968-69 began to come into view, Bill Cavanaugh sensed this and suggested that my sabbatical project might be a series of lectures to people from industry, giving them some of the basic facts of acoustics that might help them solve some of their own noise problems. Several of us had already been asked many times to give short talks or after-dinner speeches on acoustics to non-acoustical professional groups; and it was becoming apparent that the noise regulations of the Walsh-Healey Public Contracts Act were going to be elevated to a prominent position, thereby reflecting the U.S. Government's interest in achieving quieter conditions for workers in very noisy plants. Many were so noisy, in fact, that noise-induced hearing damage was beginning to be acknowledged as a serious menace in industry.

From my earlier years at BBN, working for many clients across a wide spectrum of engineering and industry, I honestly believed that I could put together a course that would be useful to the attendees. However, my consulting work and the prospects of a noise course were clearly divided into two general categories, quite apart from each other: (a) noise in manufacturing plants and industrial/commercial situations; and (b) noise and vibration produced by the heavy electrical and mechanical equipment used in large buildings to provide heating, ventilating, and air-conditioning (HVAC) for the occupants of those buildings. In those relatively early years of BBN's existence, a few of us had to work with the total range of noise and vibration problems brought to us by our clients. There was not enough work to justify specialization of specific people into specific types of work. As a result, I was exposed to a wide range of noise and vibration problems and all of us at BBN (through a concerted effort to share problems and solutions) helped each other whenever and wherever possible. Thus, in that sort of environment, I began to feel qualified to work on this rather huge range of problems, knowing that I could refer the really tough and unfamiliar jobs to others who might be able to assist.

All of this came together in a positive way when the sabbatical presented itself, and Cav made his suggestion. Of course, you can't solve all problems from a speaker's lectern, but a part of a consultant's job is to explain and simplify some of the intricacies of noise and vibration control to the client. I had worked on so many HVAC jobs and so many manufacturing plant noise problems, I felt reasonably comfortable taking on such a job. So, I began assembling material and writing two sets of lecture notes – for the two general subjects of "Noise and Vibration Control for Mechanical and Electrical Equipment in Buildings" and "Noise in Manufacturing Plants." For our own simple ease of reference, we shortened them to 'N&V' and 'MFG.' We planned two days for the N&V course and one day for the MFG course. A major problem was the designing and making of slides and audio tapes to be used in the course presentations. I even visualized that I could include a short one-hour session on noise measurements, so we contacted General Radio Company in Concord, MA (instrumentation manufacturers) to ask if we could borrow eight sets of sound level meters and octave band analyzers, plus other related equipment, to be carried around the country. General Radio agreed and even offered to help subsidize some of the travel costs. I chose the cities that I wanted for our lecture circuit and the GR travel office then proceeded to arrange for Holiday Inn Motels in those cities (using the assistance of their own field representatives in those regions). And, I got the use of all that GenRad noise measurement equipment – for that first year, and for many years still to come.

In the meantime, I began to determine my equipment needs for the lectures (PA system: loudspeakers, amplifiers, magnetic tape recorder and playback; slide projector, demonstration materials, etc.), and I made arrangements with our own Printing Shop to produce a few hundred sets of lecture notes. I could not imagine taking all of this stuff by air to six different cities, and then renting autos or hiring taxis for all the transportation needs that I could foresee, so Lucy and I made a tremendous decision: We decided to buy a travel trailer; it would have to be large enough to transport all our stuff and provide living quarters for the two of us when we were traveling from city to city. We found one, a 31-foot Airstream; then we had to buy a bigger car to pull it.

You cannot imagine the apprehension (fear) that I had in driving off the Airstream lot with that big piece of machinery hooked on behind our new car. It's not so bad when you are driving forward, but just wait until you have to back-up. We picked our places so that there was always a minimum of backing. I used the Weston school parking lot on Sundays to practice backing up. It took a lot of patience and perseverance and slowly developing ability. When we finally felt qualified to take it out on the road, we arranged for an overnight at a trailer park in New Hampshire. We arrived late in the afternoon and had to back-up in order to get into the allotted space. Whew!!!

Meanwhile, I was finishing up the assembling of all the materials that we would need for our lecture trip. We had already selected Seattle, Denver, Houston, Atlanta, Charleston, NC, and Washington D.C. as our cities. Our trip started on September 3, 1969 and ended on December 14, and we logged about 15,000 miles total (unbelievable but true). We had a total of approximately 380 'students' for the two courses in the six cities, with attendances ranging between about 20 and 60.

I could write a book on all the details, experiences, problems, and pleasures that we had with the noise courses that first year, but I must mention a few highlights. On the way to Seattle, we stayed

in the Grand Tetons while I laid out an hour-by-hour agenda for our meetings. While there, we were visited each morning by a mother doe and her young fawn. They came right up to our Airstream, just checking us out. On one of those days, Lucy went white-water rafting on the nearby Snake River. In Seattle, one afternoon, we drove by the Boeing Field and witnessed some of the taxiing and braking tests conducted on a B-52 Bomber. Its tires were smoking! When we arrived the first morning at our Seattle Meeting Room, the room was a mess, students were standing around, and I was desperate. We learned that the Manager had had a tooth extraction that morning and had forgotten to tell his staff of our requirements. We all pitched in, moved chairs and tables, and set up the room and got started – a little late and certainly a horrible way to start our lecture series in our very first city. Houston had a different problem. On our first day, they completely forgot us at lunchtime. That first year, we were buying lunches for all the attendees! I herded all of our people into their Dining Room and talked for the hour while the restaurant staff was preparing and serving us.

In Washington D.C., we faced another situation. We had visited the motel people earlier as we always did. We found that our Meeting Room was quite small, so they placed us in a room that was connected by a curtain to the next adjoining room, in case we needed more space. In the meantime, Frank Sirois (our BBN Business Office contact who had been following our work) decided that he would like to see us at work, so he arrived unannounced. During the registration time, first thing in the morning, people kept coming in who had not previously registered. Lucy was very accommodating and handled them graciously with ease. But we filled up the room to overflowing! The motel people opened the curtain to give us some additional space. Unregistered people kept arriving; the motel opened up the next curtain and brought in more chairs and tables. We ended up with about 20 to 30 people who had not previously registered. Frank was really impressed with the way that Lucy was taking care of all this excitable, unexpected situation. Then, after he saw Lucy also operating the slide projector so knowledgeably all day long, when he went back to Cambridge, he said that if we do this again, Lucy should be on the BBN payroll.

We returned home to Weston on Sunday afternoon, December 14. As soon as we had backed the trailer into our side yard, it started to snow. A good time to get home.

There were plenty of headaches, but altogether it was a most successful venture for us two neophytes on the lecture circuit. I did the talking and Lucy did almost everything else: registering the students; running the noisy slide projector (glass "lantern slides" in those days); contacting the motel when they were late for our coffee breaks; generally being a "house mother" to all the registrants of our courses; telling them about local restaurants and sight seeing places; having local maps; giving directions; etc.). Lots of details are omitted here, too. And the courses had some side benefits. When attendees couldn't solve their own simpler noise problems back at home, they had the confidence to come to BBN for more complicated problems. When the Occupational Safety and Health Act was passed on January 1, 1970, legislated pressure was placed on industry to start solving their own noise problems.

Each year, BBN had to judge if the courses were worthwhile from a financial and consulting point-of-view. They just barely paid for themselves, but we learned that they definitely had a following in the outside world. There were clear indications that they were bringing in other jobs to BBN at its various offices across the country. So, each year, I had to get BBN approval for another year of lectures and then start working on brochures, mailing lists, brochure mailings, hotels/motels, improved and enlarged lecture notes, slides, travel plans, etc. Over the next several years, the two-day N&V course increased to three days and then to four days, and the one-day MFG course increased to two, three, and four days. After OSHA became fully established, I added a one-day course on the Administration of an OSHA Program; that was for company administrators who would otherwise know nothing about noise and its vagaries. In the midst of all that, I had another sabbatical in 1974 and still another one in 1979. Much of those were engaged in a major re-working of our Lecture Notes, and in 1981, with a book-size set of completely updated Lecture Notes, we combined

This photograph shows why we bought an Airstream trailer to be used when we were on the lecture trips! In that pile of stuff, all safely packed in boxes or cases, are the following: one Kudelski magnetic tape recorder, two power amplifiers (one was a spare, which we needed one time), two loudspeakers, eight GenRad precision sound level meters, eight GenRad octave-frequency-band analyzers, eight GenRad microphone calibrators, about four boxes of lecture notes, two or three cases of demonstration material and literature, two cases of small equipment and miscellaneous cabling, Bob Newman's famous "Black Box Experiment," a slide projection screen (in case the hotel/motel would not have one), my brief case and three suitcases of clothes, and two things that require special explanations. When I started these noise courses in 1969, 35-mm colored slides and slide projectors were not yet in common use, so we had one of those old-fashioned glass lantern slide projectors (which made so much noise, I fabricated a muffler for the air intake and another one for the air exhaust; they are seen at the right side of all that collection). In due time, we converted over to 35-mm. I also had a two-wheel dolly because I knew that we could not afford bell hops twice a day to carry all this stuff back and forth between our sleeping room and our meeting room. But the dolly was a very awkward size and shape, so I had our Machine Shop cut it into three short lengths and provide a bolting arrangement so that it could be disassembled and would fit into one large carrying case. Now, nearly 40 years later, I cannot remember how we stored all those things in the Airstream, nor how we got it all in our car to go to the hotel/motel for the noise course while we left the trailer in an RV park outside the city. Ah, youth is resourceful!

the three courses into one five-day course, and it has continued that way ever since. Meanwhile, I still managed my regular job of consulting on noise and vibration problems for BBN clients.

Bob Hoover and Reggie Keith were BBNers, too. When BBN decided to open a Houston office in 1975, Bob went there as office manager. Reggie Keith joined him a short time later. After only three years, BBN decided to close the Houston office. At that point, both Bob and Reggie and their families were securely established and decided to stay in Houston, thus leaving BBN and forming their own consulting company. At that time, Bob and I had known each other and worked together for over 30 years. At the end of 1981, I retired from BBN and was given permission to continue the noise courses on my own. In 1988, I asked Bob to be a Guest Lecturer on two subjects of his expertise. He enjoyed it; so, during the five-year period of 1989-93, I transferred the five-day course over to Hoover and Keith; each year they would take on one additional day of the lecturing. For the next three years after that, they invited me to be a Guest Lecturer at their course. It has continued with them ever since.

During all of the time since about 1970, we have been asked by various companies and organizations to tailor a course for their personnel. I conducted about two dozen such courses, and H&K have probably done about the same.

Somewhere along the way, Jack Mowry and I got to know each other. He asked me to give some talks at his NOISEXPO series (1975-81) and to write a few editorials for *Sound and Vibration* (1977-82). I even volunteered a couple since then, and he was kind

enough to publish them. I cannot deny that I love writing about acoustics and some of the jobs that I experienced. I still do it. The National Council of Acoustical Consultants (NCAC) made me an honorary member in 1994, and a year later, Bill Cavanaugh asked me to write articles for their NCAC Quarterly Newsletter. I think I have worn out two editors since then.

Let me conclude this long-winded review with the remarks that I gave when NCAC inducted me into their membership. It was at their Cambridge meeting at the MIT Faculty Club on June 5, 1994. I had some handwritten notes that morning, which I later polished up a bit. Here it is. . .

Of course, we all know that "noise is unwanted sound." Or, it's a 'din' or a 'racket.' Here, I want to stress that Noise is a Racket! I confess to you that I have succeeded in making quite a racket out of noise. Altogether, people have been paying me 52 years for doing things that I enjoy – now, that is a 'Racket!' And, for the last 23 years, I have even been lecturing about that Racket – from Vancouver to Miami, Maine to San Diego, North Bay to New Orleans, even Alaska and Hawaii.

I feel obligated to say something about acoustics to this group of professional acousticians – and how I arrived here today to this auspicious and wonderful and humbling occasion. Take it from me: I have been lucky!

1. Lucky to have received the right education at the right time under the right circumstances and under the right people.
2. Lucky to have found a girl who would live a lifetime of odd and peculiar, but always challenging and thrilling experiences in this unusual field.
3. Lucky to have been surrounded by good friends and associates who have helped me along the way – many of whom are here to share this occasion with me. I've worked with Bob Hoover more than 45 years. [Remember: those numbers applied 12 years ago!] I first came to know Leo Beranek and Dick Bolt over 50 years ago [now 62 years ago]. When I was still at the University of Texas, I knew Bob Newman; and Paul Boner was my professor and teacher – that dates back 55 years [now 67 years]. More recently, I've been helped along the way by Ira Dyer, Clay Allen, Bill Cavanaugh, Eric Wood, and many, many others from the University of Texas, the Harvard Underwater Sound Lab, the Ordnance Research Lab at Penn State and Bolt Beranek and Newman. Too many to name, but all of them I thank.
4. My luckiest break came when I was invited to join BBN 40 years ago [that was in 1954; now it's 52 years ago]. That opened for me this whole new field of acoustical consulting – filled with vital, stimulating, and challenging problems and solutions. I hope you are all enjoying the satisfaction with your work that I had with mine.

I do thank you for this honor of letting me join your elite group. I am very grateful for this most prestigious award. My advice to all of you is: keep up the 'Racket!' It's fun! S/V

The author may be reached at: laymnluce@aol.com.

P.S. – I really want to expand that PS to PSA, prostate-specific antigen test. In 1990, mine was 6.5, and my doctor didn't know what that meant, either. In 1992, it had risen to 10, and my doctor suggested that I see a urologist. In those days, any thing about the prostate was a hush-hush subject and not mentioned in polite society. A biopsy confirmed that I had prostate cancer. Almost simultaneously, I had external beam radiation, and I joined and helped foster a *Man to Man Prostate Cancer Support Group* in our area in Florida.

I mention this because I want to suggest to every male reader that your PSA is an important statistic in your life. I am still here at age 88 because I heeded that number 15 years ago. I am now receiving "hormonal therapy," and at the last quarterly measurement, my PSA was 0.06 (normally considered 'undetectable,' but my urologist knows that I want numbers). If you are over 50 (or over 40 with any cancer in your family history), please have your PSA measured at your next annual physical and then afterwards at suitable intervals to keep checking it.

There are lots more details, but I will omit them here. Find the American Cancer Society's nearest *Man to Man* group. You might learn more in their monthly sequence of meetings than you do from the annual five-minutes that you have at your doctor's visit.

Thank you,
Laymon N. Miller