First commercial uses of the W.E. 640-AA microphone. Story by Leo L. Beranek, 776 Boylston Street, Apt. E10A, Boston, MA 02199. beranekleo@ieee.org.

In 1940 the US government under President Franklin D. Roosevelt started financing civilian research in the war (then called "defense") effort. The first laboratory financed by the National Defense Research Committee was the Radiation Laboratory at MIT which specialized in microwave radar. The second laboratory financed by the NDRC was the airborne acoustics laboratory at Harvard University called the Electro-Acoustic Laboratory (EAL), then located in Harvard's Cruft and Lyman Physics Laboratories. I was its Director. Because in the USA during WWII EAL was the only airborne acoustics research laboratory and because the Bell Telephone Laboratories chose to emphasize other fields, the acoustics group there, under Harvey Fletcher, agreed to my (along with Bob Wallace) visiting the BTL and learning what we could that would help us in developing new acoustical materials and improving voice communication in combat vehicles. During one of our visits I saw a condenser microphone which they had had the Western Electric Company build for them (they told me they only had 6 or so). They called it 640-A.

As Director of the Electro-Acoustic Laboratory, I was in the process of helping the US Air force and the Navy Research Laboratory standardize their procurement methods for audio equipment. I learned that in the armed forces there was no standard measure of sound pressure against which audio equipment (microphones, earphones, amplifiers) was produced. Apparently, a few moving-coil microphones had been sent to the National Bureau of Standards for calibration and these were sent around for comparison with whatever microphone each manufacturer had. The resulting accuracy of any manufacturer's microphone was not known. When I saw the 640-A microphone, it looked like the ideal candidate for a national standard microphone. The BTL said that if the aluminum diaphragm was replaced by a stainless steel diaphragm, the temperature stability would be much better and in this configuration it could be called the 640-AA.

I then approached the Western Electric Company [the Fall of 1941] and told them that I could be instrumental in making this microphone the military standard for use in testing any audio equipment that was procured by the armed forces. The Army and Navy laboratories agreed and asked me to approach the Western Electric Company and obtain instructions for ordering it. Western Electric Company told me that they would not go in the business of selling one microphone at a time to anybody who ordered it. I asked, "What is the minimum number you will sell to one purchaser." They responded, "Fifty." So I,

personally, placed an order for 50 and they agreed to manufacture them for me, expeditiously.

I realized that these microphones would only be useful if they were accurately calibrated. I did not like the idea of sending one of them to the National Bureau of Standards and then comparing the 640-AA's one at a time with it in the second-rate anechoic chambers we had at that time.

I learned that Dick Cook at the National Bureau of Standards had shown that the reciprocity method of calibration showed promise, but he had done nothing to perfect it. I asked one of the top research men at the Electro-Acoustic Laboratory, Francis Wiener, to develop a way of accurately calibrating the 640-AA microphones using the reciprocity method. He came up with the system that is shown in Beranek's book *Acoustic Measurements*, (Wiley, 1949pp. 132-148). It was capable of calibrating the 640-AA microphones to within a 0.1 of a decibel.

But, surprise, this new equipment for reciprocity calibration showed that the international standard used world-wide by the telephone companies for measuring sound pressure was different by 1.2 decibels. We made careful tests to determine whether there were any systematic errors in the reciprocity method that we had perfected, but we could find none.

The international apparatus for calibrating standard microphones was maintained by the Bell Laboratories and the French PPT telephone company. Their calibrati*ons* were made using the thermophone method *[Beranek, Acoustic Measurements* (pp. 161-171)]. This method was invented by F. Braun in 1898. Arnold and Crandall of the BTL perfected the method and published their work in 1917. With it, a thin metal strip was suspended in a volume and an electrical current sent through it. The sinusoidal heating created a sinusoidal sound pressure variation in the volume. They could equate the current flowing through the foil to the sound pressure in the volume. The trouble was that there were convection air currents in the volume that could not be accurately quantified.

When I confronted the Bell Laboratories with the EAL findings, namely, that their standard seemed to be off 1.2 dB, they are incredulous. They could not believe that they were wrong, and by such a large amount. So they came to Cambridge, inspected our equipment, agreed that it was well constructed, took drawings back and hurriedly made a duplicate. They admitted to me in short order that the Electro-Acoustic Laboratory's calibration was correct, and that thereafter they would replace the thermophone method with the reciprocity method.

All fifty of the 640-AA's that I had bought were calibrated by Francis Wiener and I sold them one by one to military laboratories and manufacturing companies. Several were bought by the Electro-Acoustic Laboratory for its use. The records clearly show that after World War II Bruel & Kjaer manufactured their equivalent to the 640-AA and this microphone appears today to be an international standard microphone.