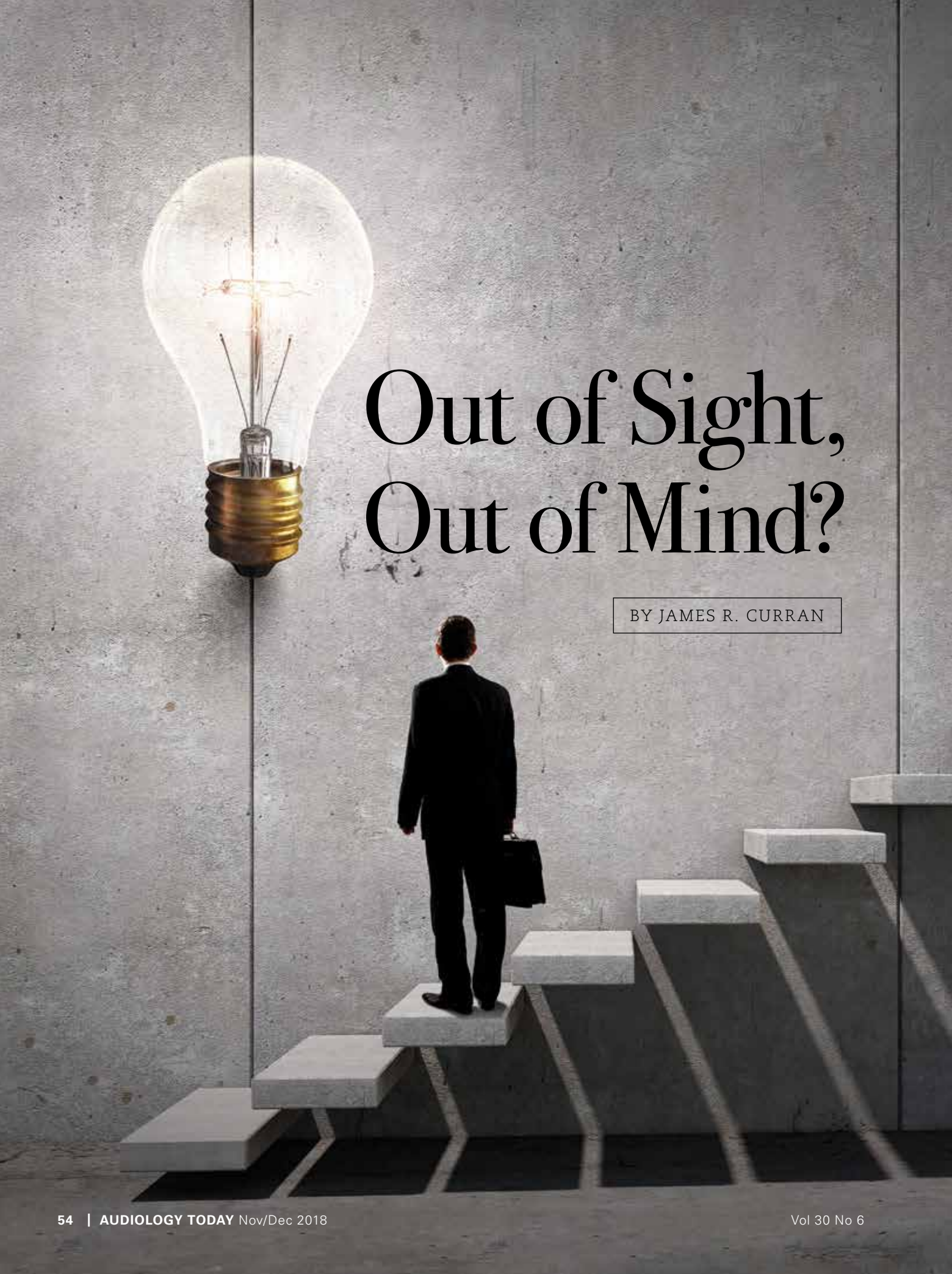

Out of Sight, Out of Mind?

BY JAMES R. CURRAN

The hearing aid industry has its share of visionary engineers and scientists who, despite unforeseen difficulties and constraints, persevered and are responsible for the advances and inventions in hearing aid amplification taken for granted by clinicians today.

Buried in the past are stories, events, and people that have been forgotten over time. As a result, the rich mosaic of accomplishments and contributions of earlier times become lost to succeeding generations. We've all read about early pioneers who braved hardship, toiled under adverse circumstances, and eventually overcame the obstacles they encountered. The hearing aid industry also has its share of visionary engineers and scientists, who, despite unforeseen difficulties and constraints, persevered and are responsible for the advances and inventions in hearing aid amplification taken for granted by clinicians today. It is a fact that the vast majority of the hearing aids that are fitted these days incorporate technology and features that were developed and invented many decades ago.

Two hearing aid company engineers with outstanding accomplishments are the subjects of this article.

In the very early years of the audiology profession, audiologists were not tuned in to the importance of hearing aid engineering and the role it played in supporting the success of daily clinical practice. There was a general attitude of skepticism about the hearing aid industry. Its claims and practices were suspect, for it generally was held that the manufacturers and dealers of the time were solely driven by monetary considerations. In one leading program, for example, audiology students expressly were directed to ignore the most authoritative book on hearing aids available, *Hearing Tests and Hearing Instruments* (Watson and Tolan, 1949).

This instruction was motivated, in part, because the book's co-author, Leland Watson, was the founder and president of Maico, a hearing aid manufacturer (Harford, 2015). Many articles in various technical and industry journals written by innovative hearing aid company engineers similarly were dismissed and rarely referenced during those early years, e.g., Goldberg (1966, 1972, 1986, 1988), Stearns (1977, 1979, 1980, 1984), Victoreen (1963, 1968, 1973, 1974), and Villchur (1973, 1973, 1978). And yet, these publications contain the seeds of today's mature technologies and applications.

There were two notable exceptions to this lack of respect and recognition—two hearing aid company engineers were accepted by both the hearing aid industry and the audiology community. Their outstanding accomplishments are the subjects of this article.

Sam Lybarger and David Preves stand apart for their technical contributions and for their unique ability to bridge the two communities over many decades. Both were effective interpreters of hearing aid technology as a result of their countless scientific publications and presentations during the years the profession broadened its scope of practice to include hearing aid dispensing.

Lybarger: Brilliant Career that Spanned Five Decades

Sam Lybarger was chief engineer (later president) of Radioear, one of the original "big four" hearing aid manufacturers in the United States in the 1920s and 1930s. This group also included Sonotone, Acousticon, and

Western Electric (see FIGURE 1). Lybarger captured and maintained the deep respect and continuing interest of the audiological community from its earliest years.

After earning a B.S. in engineering from Carnegie Tech, Lybarger joined Radioear in 1929, his first job after graduating. His experience spanned work in the carbon hearing aid era to the beginnings of transistor amplification. His products were viewed as the jewels of the industry. Their design, fit and finish, and performance were of the highest order and set them apart from the competition.

In the course of a brilliant career that lasted from the early 1930s until the 1980s, this influential hearing aid company engineer introduced notable innovations, including, among others, the invention and application of the half-gain fitting rule (Lybarger, 1944a, 1944b, 1963) that played a formative role in the early development of modern prescriptive fitting formulas.

More than 75 years ago, he designed and patented the clinical bone-conduction oscillator that is still routinely used in audiometric testing today (Lybarger, 1941). He invented and patented the first telephone coil (Lybarger, 1950), an invention that continues to be one of the foundations of present-day wireless amplification, and was responsible for the first reliable, usable dynamic (magnetic) hearing aid microphone (Lybarger, 1947, 1951). This enormous breakthrough essentially ended the use of crystal microphones in hearing aids (Curran, Galster, 2013; Berger, 1984).

It was Lybarger, with his steady, unassuming, and determined presence, who, over the years almost single-handedly led the hearing aid industry away from a hodge-podge of differing measurement methods and practices to industrywide acceptance of a uniform methodology for the measurement and expression of hearing aid characteristics (Lybarger, 1961, 1966; Lybarger, Preves, Olsen, 1999). This was considered a signal achievement, given the restive and competitive environment that existed in the industry in those days.

Lybarger functioned as the chair and moderator of the U.S. committees for the development of hearing aid standards and was the American representative to international hearing aid standards committees (ISO) until his retirement in the 1980s (Lybarger, 1961, 1966; Lybarger, Olsen, 1983).

He is remembered fondly by previous generations of audiologists as a dignified, clear voice of integrity and balanced viewpoint, as well as for his many authoritative publications and text book chapters concerning earmold acoustics and other technical issues (Lybarger, 1967, 1977, 1978, 1980, 1985). Lybarger consistently sought the input of the audiological community and was universally held in such high regard, both in and out of the industry, that the American Academy of Audiology (Academy) named its annual award for contributions to the hearing aid industry after him—the Samuel F. Lybarger Award for Achievements in Industry.

Preves: In the Forefront of Change

Hearing aid company engineer David Preves had a similar, and perhaps an even greater, affect on the audiological community. Preves recently retired from Starkey Hearing Technologies.

His career commands special attention, due to his many and significant inventions and technological contributions and because he was in the forefront of change as the industry transitioned from primitive analog products to today's modern digital designs. In fact, Preves became one of the earliest recipients of the Academy's Samuel F. Lybarger Award for Achievements in Industry.

While in his teen years, Preves dreamed of becoming a professional musician like his father, who served for 47 years as principal violist of the Chicago Symphony. This dream lasted until his father pointed out that there were no help-wanted ads for musicians in the *Chicago Tribune* newspaper, but hundreds of ads for engineers.

Preves got the message and earned a BS and MS in electrical engineering at the University of Illinois. After a short period with Control Data, out of curiosity he answered an ad in 1970 for a manager of the engineering department at Maico.

At that time, Maico was one of the largest hearing aid manufacturing companies in the United States, and the first commercially successful audiometer manufacturer. As an example of the company's importance: In 1938, Maico introduced the first audiometer to use average normal pure-tone thresholds as audiometric zero.

Preves was hired, and, in his own words, was "bitten by the hearing aid bug," intrigued by the wide array of skills and knowledge the job encompassed—acoustics, electronics, mechanical design, human engineering, and manufacturing.

When he began at Maico, ITE aids (the vast majority modular) commanded 5 percent of the market; the rest were BTE, eyeglass and body aids. He found himself struggling with the vexing industrywide problems of the time, including inadequate battery capacity and voltage, physical-size constraints, acoustic feedback (both internal and external), reliability of parts, and the demand for quality amplification using a sparse number of components.

In those years, Maico had a wholly owned subsidiary in Germany, known as Willco. On a visit to Maico in the early 1970s, Willco engineers enthusiastically extolled the virtue of a new experimental hearing aid they cobbled together. Based on the work of a PhD candidate in Germany (Frober, 1970), they had fashioned a prototype BTE that they claimed blocked out all the noise in the environment except speech coming from the front. Of course, their claim was overly exaggerated, but Preves was fascinated by the idea of a directional-microphone hearing aid.

He explored the early literature from the broadcasting industry that had developed directional microphones for studio use in the 1930s and 1940s, e.g., Baumzweiger (1939), Bauer (1942), and Olson (1939, 1944).

Willco inserted a shank of horsehair into a hole cut into the rear of the hearing aid microphone to cause the necessary delay of the acoustic signal. This obviously was not the answer.

Preves first fabricated metal and plastic plates with holes in them, but they were quite thick and resisted the fine-tuning necessary to establish the correct front-to-back ratio. The breakthrough came when Preves contracted with Buckbee-Mears, a St. Paul, Minnesota, company, that made ultrathin, electroformed metal mesh screens for use in the television industry (Preves, 2017). The resultant rear screen was thin, relatively sturdy, and reproducible.

First Commercially Successful Directional Microphone Hearing Aid in the United States

In his research, Preves discovered and reported (1974) that, by adjusting the degree of delay afforded by the size of openings in the screen, he could produce a directional cardioid response, a supercardioid response, or a hypercardioid response, as desired.

As no other instrumentation was available at the time, he developed a crude method to adjust the desired response/delay. As each aid came off the production line, it was mounted in a homemade semi-anechoic chamber, and a technician poked holes in the rear screen with a fine needle as the aid was rotated 180 degrees (Preves, 1974, 1975a, 1975b, 2017).

Thus, in 1974, the first commercially successful directional-microphone hearing aid in the United States was born, the Maico 100. The development of directional amplification is considered one of the most revolutionary technical advancements in the history of hearing aid amplification.

Preves wrote germinal papers explaining and evaluating directional characteristics (Preves, 1974, 1975a, 1975b), eventually receiving a patent for his directional hearing aid design (Preves, 1976). Based on the directivity measures that had been developed in the 1940s (Bauer, 1942; Olson, 1944), he explained the superiority of the supercardioid response in hearing aids over the cardioid response (Maico, 1975; Preves, 1975b).

The literature reveals that many audiologists at that time were skeptical of directional aids. Their reasons varied, including those who mistakenly interpreted directionality to mean localization, inappropriate directional measurement procedures, and lack of observed benefit in new patients, who had nothing with which to compare it (Lentz, 1974).

In 1975, realizing that the field was beginning to shift from BTE to ITE aids, Preves accepted a position at Starkey Laboratories as vice president of engineering. At Starkey, he published the first studies quantifying the advantages of the ITE microphone placement in the concha, showing that its location preserved the increase

in high frequencies afforded by the pinna, head, and body baffles (Preves and Griffing, 1976a, 1976b, 1976c, 1976d, 1977b, 1980). The articles, book chapters, and research papers he published in those years remain the essential canon for understanding custom amplification, including the improved intelligibility of speech in noise afforded by ITE microphone placement, the usefulness of ITE aids in cases of severe and very severe hearing loss, and importantly, the first studies demonstrating the application and function of directional microphones in custom hearing aids (Preves, 1977a, 1977b, 1994; Shapiro, Preves, 1980).

Back to School with Goal to Improve Hearing Aid Design

During this time at Starkey, Preves enrolled at the University of Minnesota to better understand the auditory system, with the goal of improving hearing aid design. He obtained his PhD in biomedical engineering.

Having been frustrated by the inability to achieve greater gain in hearing aids because of acoustic feedback, he chose as his dissertation topic the development of a phase-shifting feedback reducer. His work is among the earliest on that topic, and although it provided a successful solution, was not feasible at the time due to the large size of available components (Preves, 1985).

Preves eventually succeeded Lybarger in the standards area, becoming the de facto and then appointed successor as chair of the American National Standards Institute (ANSI)/Acoustical Society of America (ASA) S3/WG48 Working Group for the development of hearing aid standards.

For more than 35 years, Preves was the face of the hearing aid industry in domestic and international hearing aid regulatory affairs. He acted as Hearing Industries Association liaison with the Food and Drug Administration and Federal Trade Commission and represented the United States in its relationship with the International Electrotechnical Committee (IEC) as a member of its hearing aid standards technical committee TC29/WG13. He was appointed by the ASA as the co-chair of the technical advisory group for the U.S. delegation to IEC TC29 meetings, leading the effort to formulate compatibility between ANSI and IEC hearing aid standards.

He was a member of several additional ANSI and IEC working groups, including the Institute of Electronic and Electrical Engineers (IEEE)-ANSI working group that developed the standard for assuring compatibility between mobile communication devices and hearing aids.

His services were in high demand. Preves migrated in 1985 to a start-up company, Argosy, where he developed and patented the so-called "Manhattan" hearing aid, an early product (Preves, 1988) that provided the automatic reduction of low frequencies as broadband input levels increased.

Continuing in this vein, Preves (1992) patented an analog three-channel compression circuit, wherein the bandwidths and gain of each channel could be adjusted independently by means of onboard trimmers, or in the case of custom hearing aids, by a diminutive handheld wireless programmer. These signal-processing circuits, advanced for the time, were designed and built primarily with analog components. The use of digital technology in hearing aids was barely underway.

Preves left to become vice president of research and development at another new company, Micro-Tech, which specialized in custom amplification. There he invented and patented (Preves, 1998) the dual-microphone directional hearing aid system for custom hearing aids that eventually became the preferred method for providing directionality in hearing aids. This system allows switching from omni- to directional-amplification modes by means of a user-operated switch or remote control. In 1999, Micro-Tech was acquired by Starkey Laboratories.

Preves made a brief detour to become vice president of research and development at a start-up, Songbird, designing and patenting the first disposable hearing aid (Preves, 2006). Ahead of its time, the technology did not meet with favorable acceptance from the dispensing community.

His later years back at Starkey Laboratories found Preves active in developing wireless hearing aid technology, including the first systems for near-field magnetic induction (NFMI), 900 MHz radios that are still in use today, and one of the first systems for the wireless programming of hearing aids.

Preves served as the chair of the S3/WG48 and a member of the IEC TC29/WG13 standards committees until his retirement in October 2017. While finishing his career at Starkey, Preves devoted his considerable expertise to technical patent management, evaluated and summarized the many patents issued by the other major hearing aid companies, and mentored Starkey inventors.

In all, during his productive and long-lasting career, Preves received 34 patents for hearing aid designs and inventions. Without question, his contributions have left a lasting imprint on the hearing aid industry.

James R. Curran, MS, recently retired from Starkey Hearing Technologies after nearly 45 years in the hearing aid industry. He is among the first dispensing audiologists, having opened an office in 1967. A member of many industry organizations and professional societies, he is a former member of the Academy's Board and the executive committee of the American Auditory Society. In 2013 he received the Academy's Samuel F. Lybarger Award for Achievements in Industry.

There are many other pioneers in our industry, both well known and unknown, some remembered, most essentially forgotten. All have had an important and lasting effect in amplification

technology critical to rehabilitative audiology. Each deserve acknowledgment for their individual contributions. Many names could be mentioned; the list is long. All have quietly contributed with passion and ingenuity to the resolution of nearly insurmountable technical problems involved in developing and furthering the art and science of the acoustic treatment of hearing loss with amplification.

The author wishes to thank Jason Galster for his assistance in preparing this article.

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