MASSA PRODUCTS CORPORATION
280 LINCOLN STREET, HINGHAM, MA 02043-1796 U.S.A.
781-749-4800 FAX: 781-740-2045 www.massa.com

GENERATIONS AHEAD IN SONAR & ULTRASONIC TECHNOLOGY

Electroacoustic Transducers and Systems Are Not the Same as Electronic Components

By Dawn F. Massa Stancavish, Chief Innovation Officer & COO, and Donald P. Massa, President & CTO

Electroacoustic Transducers are a critical component of ultrasonic and sonar sensing devices. Interestingly, as important as they are, there are few in industry that fully understand them. This paper seeks to educate on the complexity of these devices and challenge the misconception that transducers are a commodity component that anyone is qualified to build, buy, or sell with the idea that its performance, construction, and/or value is relatively comparable.

Transducers are devices that transform one form of energy into another. A few acoustic transducers, such as whistles or musical instruments, transform mechanical energy into sound, but the following discussion will be primarily concerned with electroacoustic transducers. They are classified as either transmitters that convert electricity to sound, or receivers that change acoustic energy into electrical signals.

The invention of the telephone in the late 1800s resulted in the first widespread use of electroacoustic transducers. The microphone in the telephone converted the acoustic energy of the human voice into electrical signals. The earpiece in the telephone converted the electrical signals back into acoustic energy so the voice of the person at the other end of the line can be heard.

New requirements for different types of electroacoustic transducers were created by the development of the phonograph at the turn of the last century, followed by increased consumer use of radio in the 1920s and the advent of sound motion pictures in the 1930s. Improved loudspeakers and microphones were required to meet the demands of these new industries, and the science of sound was transformed into the applied science of electroacoustics.

During the 1920s, electrical engineers began applying the concepts of "equivalent circuits" to characterize acoustic transducers. The mechanical and acoustical portions of the transducer were modeled by converting them to equivalent electric circuit components of inductors, capacitors, and resistors. These equivalent circuit elements of the acoustic portions were coupled to the pure electrical portions of the transducer by means of an electromechanical transformer. This modeling allowed the pioneering generation of electroacoustic engineers to not only better understand how transducers operated, but also to optimize transducer designs by using the well-known methods of electric circuit analysis. In 1929 the Acoustical Society of America was formed, and in 1934 the first engineering-based textbook on transducers, entitled *Applied Acoustics*, written by Frank Massa and Harry Olson, was published.

While significant improvements in the design of electroacoustic transducers for use in the audible frequency band in air were achieved during the first three decades of the last century, a new requirement for electroacoustic transducers to operate underwater for sonar applications was only in its infancy. However, the military threat of submarines during World War II caused sonar transducer development to rapidly advance during the 1940s.

Following World War II, new types of electroacoustic transducers designed to operate in the ultrasonic frequency range were developed for a wide variety of new industrial applications, such as non-contact distance or level measurement, collision avoidance, communication,

remote control, intrusion alarms, ultrasonic cleaning, ultrasonic welding, ultrasonic flow detection, and ultrasonic imaging. Different transducers were designed to operate at frequencies as low as 20 kHz, the upper-frequency limit of human hearing, to 10 MHz and higher [1,2,3].

If an ultrasonic transducer is needed, it is important that you choose the correct transducer for the application. There are many things to consider in selecting the correct transducer, such as the frequency of operation, the radiation pattern of the transducer, the transduction material, and the basic type of electroacoustic design to use.

It is also essential that you choose the proper manufacturer. How do you know that you are buying a quality product? The necessary cornerstones of a good transducer manufacturer include having strong and qualified acoustic engineering and production engineering departments. Too often in today's world, the consumer has fallen victim of faulty production engineering. Nearly everyone has experienced at some point in their life a purchase fall apart not due to misuse or abuse, but rather because it was not designed well for manufacturing, and thereby poorly built.

With electroacoustic transducers, especially in the commercial markets, some people think a transducer with the same performance specs listed purchased from any supplier is a comparable product. All transducers are not created equal. Often a design that has been around for numerous years might eventually have "copycat" transducer models from numerous manufacturers in the market. However, just because there may be a standard build or drawing package available IP always is hidden in the process. A quality transducer and sensor manufacturer will always be able to manufacture a superior product when they have strong material knowledge and a solid fundamental understanding of the acoustic properties of the necessary components. In addition, a good manufacturer will have electroacoustic design engineers available to discuss your application in detail with you to make sure that you are buying a transducer with the optimum design to meet your needs. If they cannot supply you with a product that is the best fit for your application, you should discuss what would be involved with having them design something for you. This is also the benefit of working with a supplier that has design and manufacturing capabilities as opposed to just buying from a regular factory or distributor.

Ultrasonic electroacoustic transducers are complex structures that are fabricated with precision parts that often have tolerances that are less than .001 inches. They must also be manufactured with high tolerance jigs and fixtures and critical process sheets developed by experienced production engineers with many years of experience in the specialized field of electroacoustics. If it is properly designed, an ultrasonic transducer will operate for decades without any degradation in performance, thus adding to their value. Whereas the majority of electronic products on the market devalue and become obsolete over time. Ultrasonic transducers are also not a commodity item that can be properly copied and reproduced by low-cost overseas manufacturers. Such companies would not have the proper electroacoustic design engineers and production engineers to make a reliable product. The fundamental designs of ultrasonic transducers also never become obsolete, like what happens with most electronic devices.

A number of whitepapers, publications, and historical articles that contain more specific detailed information regarding ultrasonic transducer designs are contained in the "Resources" section of the Massa Products Corporation website, www.massa.com. Some specific ones are listed in the Bibliography of this article, numbers 4-7.

BIBLIOGRAPHY

1. F. Massa, *Some Personal Recollections of Early Experiences on the New Frontier of Electroacoustics During the Late 1920s and Early 1930s*, J. Acoustic Soc. Am. 77(4), April 1985.

2. F. Massa, *Sonar Transducers: A History, Sea Technology*, November 1989.

3. H. Olson and F. Massa, *Applied Acoustics*, Philadelphia; P. Blakston's Son & Co., Inc., 1934.

4. D. Massa, *Choosing an Ultrasonic Sensor for Proximity or Distance Measurement, Sensors, Part 1* – February 1999, Part 2 – March 1999.

5. F. Massa, *Radiation of Sound, American Institute of Physics Handbook*, Sec 3, Pgs. 118-122, McGraw-Hill, 1963.

6. F. Massa, *Ultrasonic Transducers for Use in Air*, Proceedings of the IEEE, Vol. 53, No. 10, 1965.

7. *An Overview of Electroacoustic Transducers* by Donald P. Massa.