How They Did It: Inside the SM58®

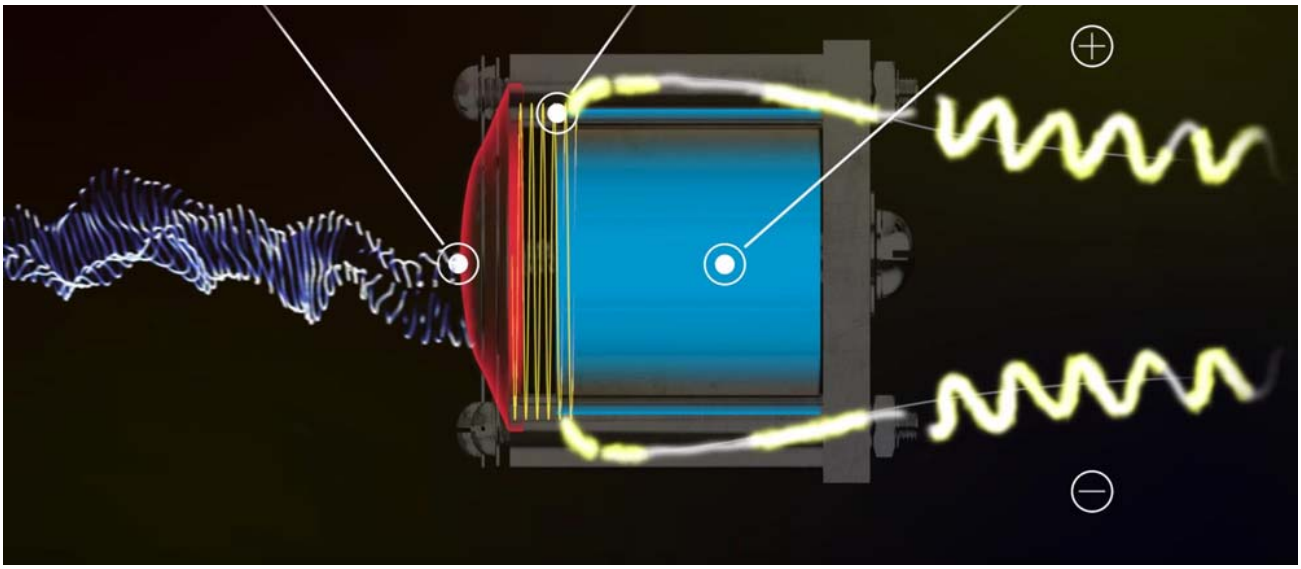
Written by **Michael Pettersen** on October 20, 2016 under **Education**

Crisp, clear sound. Fantastic low end. Great on vocals. Virtually indestructible. Rock solid. The standard bearer.

Like most performing legends, the **SM58** makes it all look so easy. But making the leap from the original 'birdcage' style Unidyne models to the 'new', smaller handheld style was a real challenge. Shure engineers Ben Bauer and Ernie Seeler wanted to improve on the frequency response and directionality of Bauer's original Unidyne design, while making the transducer much smaller to fit in a handheld microphone. The handheld form factor added some new concerns: p-pop protection, vibration isolation, and symmetry – things that were rarely an issue with large stand-mounted microphones that didn't move around.

How these SM58 came to be can largely be attributed to three mini-miracles of microphone engineering: the diaphragm, the transducer and the shock mount. We'll look at them one by one.

First, though, a crash course in how a dynamic microphone converts sound waves into electrical energy.



Dynamic Cartridge

Like all dynamic microphones, the SM58 employs a diaphragm/voice coil/magnet assembly that forms a miniature sound-driven electrical generator. Sound waves strike a thin and light membrane called the diaphragm, causing it to vibrate. The voice coil is attached to the rear of the diaphragm and vibrates with it. The voice coil is surrounded by a magnetic field created by a small magnet. The motion of the voice coil in the magnetic field generates the electrical signal corresponding to the sound picked up by the microphone.

The Diaphragm Design

When Ernie Seeler designed the diaphragm for the Unidyne III transducer used in the SM58, he set out to solve one of the biggest challenges of microphone design: diaphragm flexing. Diaphragms tend to flex differently depending on whether they are struck by bass, midrange, or treble frequencies. This means that the movement of the coil will not correspond exactly to the soundwave, and will cause noticeable variations in sound quality.

Seeler used Mylar™ polyester film for the new diaphragm – a particular form of plastic that is very rigid but also very light, so it would move easily in response to subtle sound waves but not flex much. He molded the diaphragm with a unique shape: like a doughnut, but with a dome in the middle. These features make the diaphragm and voice coil move up and down uniformly as one piece, with little flexing, regardless of

improvement of high frequency response. This design helped to give the SM58 its smooth, balanced sound across the frequency range.

The Transducer Design

Ernie Seeler wanted the Unidyne III cartridge to have “uniform polar response over the entire audio spectrum” — in other words, the cardioid pattern would be the same at low, mid, and high frequencies.

He also wanted it to be “rotationally symmetrical”, meaning that the sound and the pickup pattern would be consistent no matter how the mic was rotated around its axis. In the 1930’s, 40’s, and 50’s, this wasn’t very important because performers stood in front of a microphone on a fixed stand. Most microphones at this time had polar patterns that were quite different above and below the mic, but it didn’t matter because the performer didn’t move in relation to the microphone, and the microphone didn’t move in relation to the loudspeakers.

In the 1960’s, as rock and roll grew in popularity, performers wanted to be able to hold the mic while moving around the stage and not be restricted to one location. Since the microphone’s position relative to the performer and to the loudspeakers could vary, it became important that the microphone’s sound quality was consistent no matter how it was oriented.

When designing the original Unidyne, Ben Bauer had devised an ingenious ‘front door/back door’ system (called the Uniphase principle) that provided two pathways for a sound wave to reach the microphone diaphragm. Sounds from behind the mic reach both the front and the back of the diaphragm at the same time. Like two people pushing on opposite sides of a door, the forces cancel each other out and the diaphragm doesn’t move, so no signal is generated.

Seeler adapted the Uniphase principle to work in the much smaller handle of newer hand-held models like the **545**, **565**, and SM58, and improved its directional capabilities across a wider frequency range by adding a complex network of openings, screens, and cavities that act as an acoustic network.

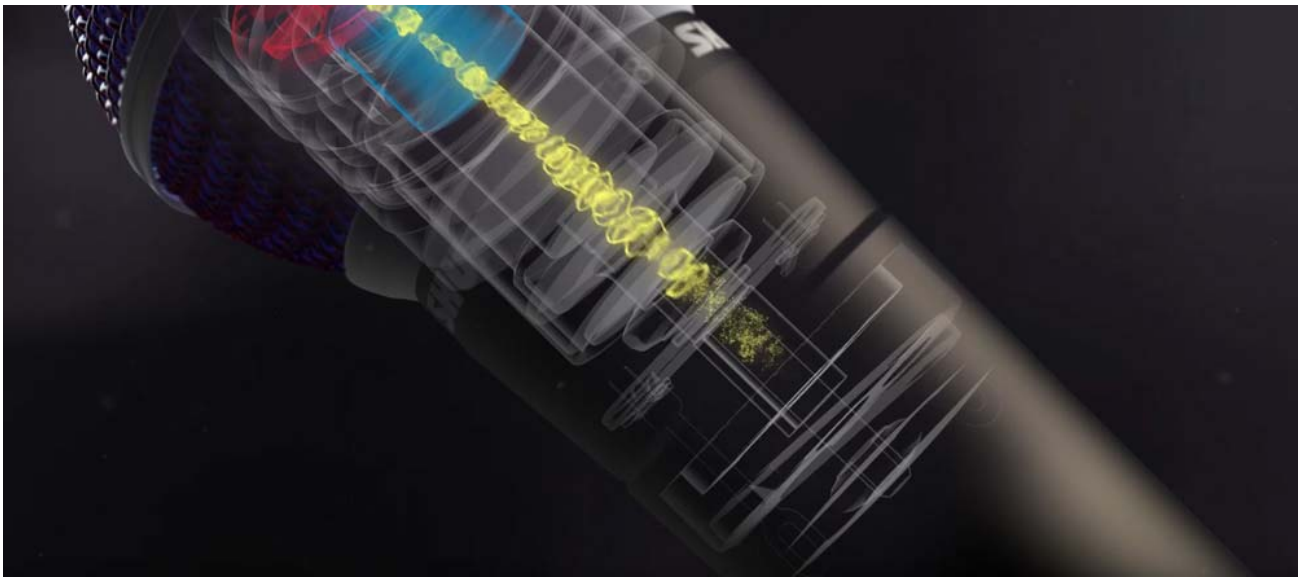
greater freedom to connect with the audience while allowing sound engineers to deliver more gain without feedback from the more powerful PA systems needed to handle larger venues.

The Shock Mount

Deep in the SM58's handle is another technological innovation: a shock absorber for physical vibration. A microphone diaphragm is designed to be moved by the miniscule energy of sound waves alone. It has to be extraordinarily sensitive to do this, but that means that it is also highly sensitive to vibrations coming through the microphone handle when it is touched.

The simple solution is to mount the transducer in one or more rubber rings, which absorb some of the vibration energy. But every microphone is sensitive to some types of vibration more than others, and some vibrations have a more audible effect than others. Instead of the one-size-fits-all approach used in lesser microphones, Seeler designed a unique shock mount specifically for the Unidyne III transducer used in the SM58 – one that could actually be tuned to control vibrations in the most critical frequency ranges where vibrations posed the biggest threat to sound quality.

The shock mount is the unsung hero of the SM58's performance. Tap on a cheap microphone and it will resonate like a drum; tap on an SM58 and you'll hear only a dull, muted thud. The shock mount is the reason why performers like Roger Daltrey can be as rough as they want with the 58, to the point that it becomes part of their act.



Shock mount inside SM58

Engineering Then and Now

Legend has it that the development of the shock mount alone involved over 300 hand-written mathematical computations. How many hours were spent researching, testing and retesting the materials required to make the principle work perfectly in a microphone slated for mass production is unknown.

One person who understands the SM58 intimately is Principal Engineer Yuri Shulman. While the development of the Unidyne III cartridge predated Yuri's arrival at Shure in 1981, he remembers Ernie Seeler very well and recalled the primordial tools employed by audio engineers of the day.

"Ernie Seeler, just like Ben Bauer in the U.S. and Georg Neumann in Germany, was one of the most talented engineers in the past century", according to Shulman. "Ernie was a giant in acoustics *and* a brilliant mathematician."

Back then, the tools of the trade were drafting boards, logarithm tables and slide rules. Frequency response was tested in a small sound room with an Ampex reel-to-reel tape machine. Mic drop tests were performed by dropping microphones from the mezzanine to the first floor. A team of machinists made parts for prototypes. *Everything* – from marketing, design, engineering, plating, molding, painting,

Contrast the limited space of the early mic development department to the 65,000 square foot Technology Annex at Shure today and you'll find some of the same mechanical devices used in Seeler's time, but there is also electro acoustical software that can produce more accurate results in seconds, not minutes or hours. Two anechoic chambers and a state-of-the-art listening room are constantly in use. 3D printers reduce prototype development by weeks. A small number of machinists (with the help of robotics) in the Tool Room do the work of many people thirty-five years ago.

There isn't much about the old days that Shulman misses, except the convenience of being able to check production a short walk away. He is emphatic that today's SM58 microphone "is dramatically improved", pointing to more precise tooling, new materials, greater consistency, better production processes and increased durability. "Today's SM58 is the best one we've ever made. Every SM58 is tested to meet all rigorous specifications before it leaves the factory. I don't know of another manufacturer that does that."

Michael Pettersen

Fascinated by music, sound, and audio technology since building a crystal radio set as a child, Michael Pettersen is the Director of Corporate History. Employed by Shure Incorporated since 1976, he is a contributing author to the 1,550 page reference tome "Handbook for Sound Engineers" as well as the

arrangements, co-author of a biography about jazz guitarist Freddie Green, and a notorious raconteur.

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