Sound Strategy

The story behind the development of 3M™ Littmann® Electronic Stethoscopes

3M researchers are redefining the stethoscope by shifting focus from what is to what could be

Much of the technological wizardry that shapes our modern way of life is the end result of a long series of incremental improvements over earlier inventions – for example, making a device a little more efficient or cheaper or more reliable. However, the most significant improvements are those that completely re-imagine an invention, enabling it to do things its original inventor never dreamed possible.

A case in point is the telephone. Despite numerous functional and aesthetic upgrades over the years, the telephone was used almost exclusively for simple two-way voice transmission for well over a century. It was ultimately the confluence of microelectronics, wireless technology and the Internet that inspired the evolution of the telephone into a powerful mobile communication device that could take pictures, play music and games, transmit data and surf the Internet. And, incidentally, make telephone calls.

In order to make these kind of "leapfrogging" technical advancements, an inventor (or team of inventors) needs to have three things: a good, general knowledge of current technological trends; a profound understanding of customer needs; and the ability to imagine how various technologies could be connected in novel ways, in order to solve their customers' challenges.

These are, in fact, the driving forces behind some exciting 3M breakthroughs in one of the medical world's most venerable (and certainly most iconic) diagnostic devices: the stethoscope.

The early heartbeat of innovation

Invented by French physician René Laennec in 1816, the first stethoscopes were simple wooden tubes with flared trumpet-like ends. Although many incremental improvements have been made to Laennec's original invention, including flexible tubes and binaural constructions, the essential function and usage of the non-electronic stethoscope remained relatively unchanged for almost 150 years.

An early Laennec obstetric stethoscope

3M's involvement in stethoscopic technology goes back to the 1960s, with the acquisition of a company founded by pioneering researcher Dr. David Littmann. Littmann's innovative design for a two-sided chestpiece, with a bell on one side and a diaphragm on the other, greatly improved stethoscope acoustics, and helped make 3M™ Littmann® Stethoscopes the benchmark of the industry.

Although to this day the majority of medical professionals continue to use the newest generation of non-electronic stethoscopes, there has long been a perceived need to amplify sounds beyond the capability of any non-electronic instrument, in order to amplify sounds that may go undetected.

Turning up the volume

Connecting an electronic amplifier and a microphone to a stethoscope might seem like an obvious solution to the problem – but amplifying heart and lung sounds in a realistic, comprehensible way proved to be an enormous technical challenge. Starting in the 1950s, when the idea was first proposed, many companies tried to produce a practical electronic stethoscope, but none were commercially successful.

Then, in 1995, 3M saw that the time was right to initiate their own electronic stethoscope development program – one that would approach the problem from both a technological and a customer standpoint.

According to Ned Hancock, Global Marketing Manager, 3M Health Care, the main goal of the 3M development team was not simply to achieve practical amplified sound, but also to develop an instrument that looked, felt and operated as much as possible like a traditional, non-electronic stethoscope.

"We wanted our electronic stethoscope to produce sounds similar to what the clinician was accustomed to hearing on a non-electronic stethoscope, only louder and clearer, to reduce the chance of misdiagnosis," says Hancock. "And we wanted its use to be familiar and intuitive, so it wouldn't require a steep learning curve."

After three years of development and clinical trials, the team launched their first commercial product – the 3M™ Littmann® Electronic Stethoscope Model 2000 – in 1998. Craig Oster, Senior Technical Manager, 3M Infection Prevention Division, remembers that time well.

"By today's standards, the Model 2000 would seem a little old-fashioned. This was an analog, rather than a digital device, without any recording or communication features. All it did was amplify sound – but it did that very well."

Entering the digital age

The late 1990s ushered in an era of increasingly rapid advancements in microelectronics and communication technology – a trend that did not go unnoticed by the Littmann team. In September of 2000, the first digital Littmann stethoscope, the Model 4000, was introduced, offering a variety of improvements over its predecessor.

"In the backs of our minds, we had always wanted the ability to record sounds with the stethoscope. With the new electronic technologies that emerged at the time, this looked like an achievable goal," recalls Hancock. "Computers were also beginning to employ infrared (IR) technology for short-range wireless communication, so we decided to incorporate this technology in the Model 4000."

The Model 4000 was the first electronic stethoscope that could transmit sounds to a computer for recording without the use of a cord or wire. It also featured a small LCD window that would display the patient's heart rate in real time. Unfortunately, infrared transmitters and receptors must be positioned so they can "see" each other in a straight line. If a person or object breaks the beam, the transmission is lost. "The Model 4000 was also relatively heavy and complicated; although the medical community appreciated its capabilities, they continued to ask for an electronic stethoscope that was simpler and easier to use," says Hancock.

Can you hear me now?

While researching technologies that could improve the communication and recording features pioneered in the Model 4000, work continued on finding ways to enhance the sound quality of Littmann electronic stethoscopes.

"We knew that many of our customers were having trouble hearing faint sounds – especially in environments, such as emergency rooms, where there was a lot of extraneous noise from equipment, monitors, voices and so on," states Oster. "We felt that one of the most important refinements we could make to our electronic stethoscopes was the ability to filter out ambient noise."

3M partnered with Bang & Olufsen Medicom, who developed the ambient noise reduction technology that would comprise the key feature of the Littmann Model 3000 stethoscope, introduced in 2005. Lighter, and with improved sound quality – but without the recording feature of the Model 4000 – the Littmann Model 3000 quickly became the best-selling electronic stethoscope in the world, earning a featured place on the front page of the Wall Street Journal. Bang & Olufsen Medicom's ambient noise reduction technology would go on to win an iF Product Design Award in 2006.

"As part of our launch efforts, we conducted a controlled experiment at the American College of Cardiology conference that demonstrated how doctors could miss important sounds when using non-electronic stethoscopes in a noisy environment," says Oster. "With the ambient noise reduction capability of the Model 3000, clinicians could hear and diagnose with confidence."

Re-writing the rules

Around the time of the Model 3000 introduction, a technology that was first developed in 1994 for short-range wireless telecommunications had begun to achieve widespread market acceptance. Called Bluetooth™, the technology makes it possible to securely connect a variety of electronic devices, without the line-of-sight limitations of infrared connections.

Two researchers on the Littmann team, Dr. Joel DuFresne and Dr. Bill Bedingham, were particularly intrigued by the potential of Bluetooth to improve the connectivity of Littmann electronic stethoscopes, and began to spearhead development work on upgraded versions of the Model 3000.

Establishing a solid, reliable communication link between a stethoscope and a single computer in the same room to record and analyze sounds would have been a worthwhile achievement in and of itself. But when you are part of a culture that is endlessly curious about connecting technologies in new ways, you are almost compelled to take things a step further.

"Part of the issue is that, even though our primary objective is to give customers what they want or need, those same customers may not always be able to articulate those needs, or even be aware of everything that may be available to them," says Hancock. "A big part of our job at 3M is to stay on top of emerging technology trends, and then basically start imagining how all these things might connect together, in order to create something of value to our customers."

Making the connection

Thus the team began to engage in some serious lateral thinking. For example, if Bluetooth made it easy to connect a stethoscope to a computer; and that computer were connected to the Internet; why wouldn't it be possible for a doctor hundreds or even thousands of miles away to be able to listen to the same patient sounds in real time? Maybe even directly through a similar stethoscope, without having to listen through a computer?

The short answer is that all of this and more was indeed possible, and ultimately realized with the introduction of the 3M™ Littmann® Electronic Stethoscope Model 3200 in 2009. "In order to harness many of the capabilities built into the Model 3200, we partnered with Zargis Medical Corporation to develop the software interface between the stethoscope and computer, allowing the user to record, visualize and share heart and lung sounds," says Oster. "They also developed an optional add-on program to help identify and document suspected murmurs."

Enabling new capabilities in telemedicine

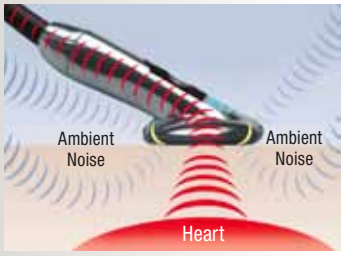
Most recently, in November 2010, 3M announced the U.S. launch of the 3M™ Littmann® Scope-to-Scope Tele-Auscultation System, greatly expanding the capability of clinicians anywhere in the world to perform remote diagnostics. "This is the same system used on-board the International Space Station by the Japanese Aerospace Exploration Agency (JAXA), allowing clinicians on the ground to hear the actual heartbeat of astronauts in space," Oster relates. "They can even speak to each other through the chestpiece, minimizing the need for a separate telephone or microphone connection."

Despite the attention received by cutting-edge features such as tele-auscultation, the driving force behind every Littmann electronic stethoscope remains a commitment to achieve the best possible audio fidelity, comfort and ease of use. Both the Model 3200 and its non-recording companion model, the Model 3100, feature 3M's advanced ambient noise reduction technology that eliminates approximately 85 percent of distracting background noises without filtering out critical body sounds. They also amplify sounds up to 24 times, even in the most challenging environments; provide frictional noise reduction, to reduce handling sounds from the chestpiece; and offer extended sound range frequency.

From René Laennec's simple "listening tubes" to today's state-of-the-art Littmann electronic stethoscopes, the science of auscultation has come a long way. If there is a lesson to be learned from that journey, it could be that innovation tends to follow a crooked path, but one with well-marked signposts: build and improve upon what has come before; seek solutions that satisfy real customer needs; and always keep an eye open for those "uncommon connections" that have inspired so many of humankind's greatest technical achievements.

How Ambient Noise Reduction (ANR) Technology Works

Ambient Noise Reduction technology reduces background noise that can interfere with the auscultation experience, up to 85% on average. Because ambient noise travels into the stethoscope both through the air and through a patient's body, the proprietary ANR technology built into Model 3100 and 3200 stethoscopes uses both sources of ambient noise to cancel each other out, leaving only the unfiltered sound of the heart, lung or body sound to be heard.



The same ambient noise that travels through the air also travels through the body. 3M's patented ANR technology cancels out both sources of ambient noise, leaving the critical body sounds that need to be heard.

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