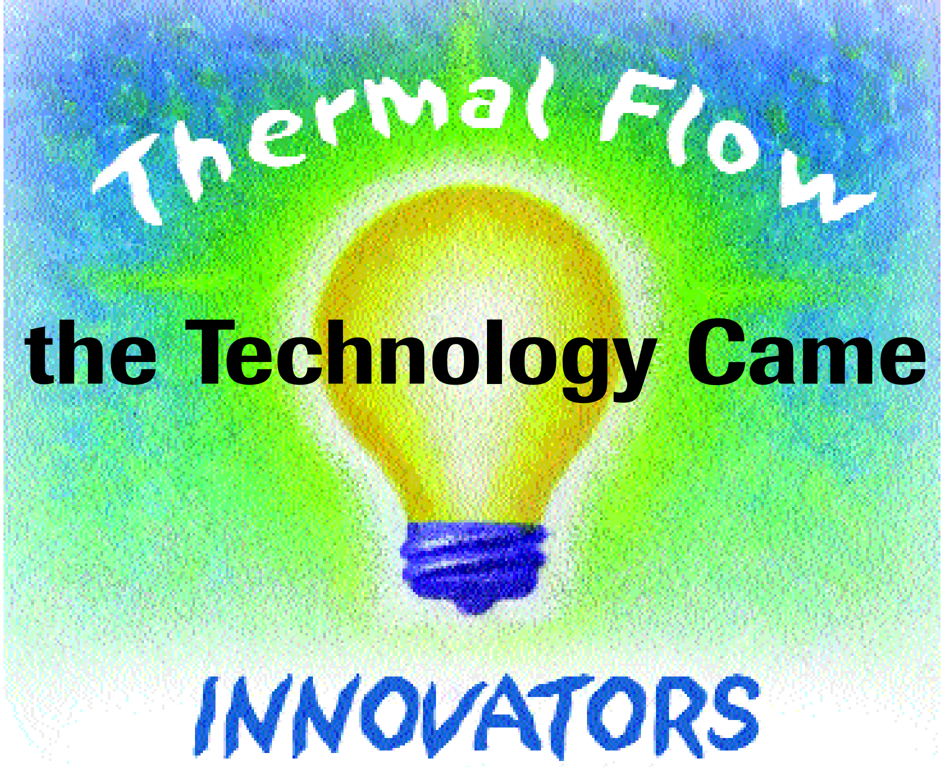


How the Technology Came to Be

By Jesse Yoder

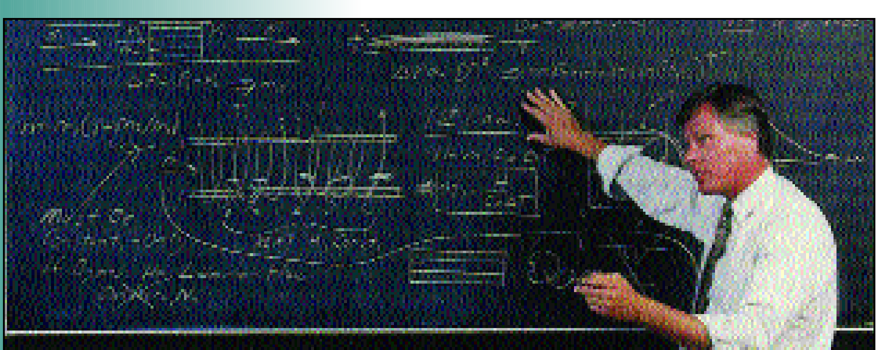
> *"Going forward, look for more innovations in thermal flowmeter technology, as suppliers continue to respond to end-user needs for reliable and cost-effective ways to measure gas flow."*

Perhaps more than any other flow technology, the history of thermal flowmeters is closely connected to the history of the companies that manufacture them. This article traces the evolution of some of the primary players in the thermal space and explains how similar thermal technologies evolved from two very different approaches.

Thermal flowmeters were developed in the 1960s and 1970s as a result of two separate lines of research. One line involved the creation of flow switches to detect the presence of flow in pipes carrying a mixture of oil and water from oil wells. Mac McQueen and Bob Deane, founders of Fluid Components International (FCI), took this approach. The second line involved adapting hot-wire anemometer technology to an industrial environment. Dr. John Olin and Dr. Jerry Kurz, founders of Sierra Instruments, took this approach.

One Approach: *Thermal Switches to Measure Oil Flow*

The story of the development of thermal flow switches began in Bakersfield, Calif. in 1964. An oil company was pumping a mixture of oil, water, and sand from as many as 30 wells into central collection points, where it was measured so that royalties could be collected. A problem arose because during cold weather, the pipes would freeze up, causing flow to stop. The oil company needed a method for determining when flow stopped in the pipes.



Dr. John Olin, founder and CEO of Sierra Instruments, is one of the founding fathers of modern-day thermal mass flowmeter technology.

At that time, Mac McQueen and Bob Deane devised a method for determining a flow/no-flow condition in the pipe, using thermal switches. The thermal switch involved a low-power heater and two temperature sensors. One temperature sensor was mounted directly above the heater. The second temperature sensor was mounted nearby, downstream from the heater.

When any kind of fluid flowed through the pipe, it carried the heat from the heater downstream. As a result, the temperature sensor above the heater and the one downstream from the heater registered about the same temperature. But when flow stopped, convection carried heat to the first temperature sensor, giving it a higher reading than the downstream temperature sensor. The difference in temperature varied between 20 F and 100 F, depending on whether the fluid was water, oil, or gas. When this difference in temperature occurred, an alarm was tripped, signaling a no-flow situation.

This switch system also worked to monitor the flow volume being pumped through the pipes. By regularly monitoring the flow/no-flow conditions in the pipes, the oil company was able to get a good idea of how much oil the field was producing to within one percent of actual value. So even though the thermal switches were not designed as flowmeters, they ended up being used as a kind of meter to determine flow volume. The thermal switches were able to do this even though they didn't detect the speed of flow; they simply detected a flow/no-flow condition.

These early flow switches illustrate a fundamental principle of thermal flowmeters. Thermal flowmeters work by putting heat into a fluid and measuring how quickly the heat dissipates, using temperature sensors. Because fluid carries heat with it, mass flow can be measured by monitoring the activity of temperature sensors placed near the heater. Heat is usually added to the flowstream by sending current through some type of wire that is mounted in the flowstream.

The thermal switches developed by McQueen and Deane formed the product base for FCI. While their early thermal switches served as a pseudo flowmeter, it wasn't until 1981 that FCI officially began producing thermal flowmeters. These flowmeters were nothing more than the previously developed thermal switches with more sophisticated electronics.

A Second Approach: *Industrializing Hot-Wire Anemometers*

During the time that Mac McQueen and Bob Deane were developing their thermal flow switches, John Olin and Jerry Kurz were colleagues in the same Ph.D. program at Stanford University. Olin majored in fluid mechanics and heat transfer and was studying a new way to generate electricity by shooting electrons through a superconducting magnetic field. This research required measuring turbulence, and to do this Olin used hot-wire anemometers from Thermo-Systems Inc. (TSI). At that time, TSI was one of several companies in the world making hot-wire anemometers for research purposes.

Thermal flowmeters have something in common with hot-wire anemometers, which were developed in the early 1900s. Hot-wire anemometers were used in velocity profile and turbulence research. They consist of a heated, thin-wire element and are very small and fragile. Because they are so small and thin, they have a quick response time. But their fragility makes them unsuitable for industrial purposes, because they break easily. Industrial environments require a more rugged device.

Several years after graduating from the Stanford program, Olin and Kurz both went to work for TSI in Minnesota. Beginning in 1968, and continuing through the early 1970s, both of them worked in the TSI research department. Included in their research were air velocity meters that were used for HVAC applications.

Eventually, both Olin and Kurz left TSI. They then worked together to develop their own thermal mass flowmeters. They were both aware that hot-wire anemometers were too fragile for industrial use. The first products developed were a portable air velocity meter and an air velocity transducer. They also developed two air-sampling products to measure particle size and distribution in the air. These products formed the basis of Sierra Instruments, which was incorporated in Minnesota in 1973.

In 1975, Olin and Kurz moved their operation from Minnesota to California, taking their air velocity meters and air sampling devices with them. After running the business together for several years, they decided in 1977 to divide up the company and the products they had developed. Olin kept the name "Sierra" and the air sampling products, while Kurz kept the air velocity products. At that time, Jerry Kurz formed Kurz Instruments, maintaining operations in California.

How Thermal Flowmeters Work

While FCI approached thermal technology from the perspective of thermal switches, and Sierra and Kurz Instruments approached this technology through hot-wire anemometers, all three companies developed products that use similar principles. As the name "thermal" implies, thermal flowmeters use heat to arrive at their flow measurements. Specifically, thermal flowmeters put heat into the flowstream and use one or more temperature sensors to measure how quickly this heat dissipates.

Heat dissipation is measured in several different ways. One method keeps a heated sensor at a constant temperature and measures the amount of current required to keep it at that temperature. Another method measures the difference in temperature between a heated sensor and the temperature of the flowstream. Both methods work on the idea that higher velocity flows result in greater cooling. Both measure the effects of this greater cooling and use that result to compute mass flow.

A Response to Environmental Concerns

In the 1980s, FCI, Sierra, and Kurz continued development of their thermal technologies along somewhat parallel lines. Then in the early 1990s, environmental regulations came along that influenced these companies in a similar way. These regulations involved continuous emissions monitoring (CEM), and they resulted in the development of a new type of thermal flowmeter.

The Environmental Protection Agency (EPA) began requiring industrial companies to do continuous emissions monitoring. The purpose of CEM was to detect and reduce the emission of sulfur dioxide (SO_2) and nitrous oxide (NOX) into the environment. SO_2 and NOX are two principal causes of acid rain.

By combining a measuring of the concentration of the SO_2 and NOX with the flow rate, it is possible to determine how much of these substances are being released into the atmosphere. The EPA program was implemented to reduce atmospheric pollution, mainly from industrial sources. An entire industry has developed around CEM, including the introduction of Continuous Emission Systems (CEMS).

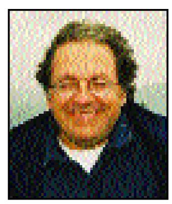
Thermal flowmeter companies responded to CEM by introducing multipoint thermal flowmeters. Much continuous emission monitoring occurs in large stacks that emit pollutants from industrial sources. Because thermal flowmeters measure flow at a point, it can be difficult to accurately compute flow in a large pipe or smoke stack based on a single point measurement. Multipoint thermal flowmeters use multiple measuring points to measure gas flow. Some multipoint flowmeters have as many as 16 measuring points. They then use these values to compute total flow in the large duct or stack.

Other Classifications

In addition to single-point and multipoint, thermal flowmeters can be classified in several different ways. FCI, Sierra, and Kurz Instruments developed thermal flowmeters that place a heated sensor in the flowstream. These thermal flowmeters are called immersion type, and are also called thermal dispersion. Insertion thermal flowmeters mount a probe directly into the flowstream. Inline thermal flowmeters mount the sensor inside a pipe, which is then mounted to a pipe as an inline flowmeter.

Looking Toward the Future

Thermal flowmeters are one of the few types of flowmeters that directly measure mass flow. They are less expensive than Coriolis flowmeters, which also directly measure mass flow. And while they are not as accurate as Coriolis meters, thermal flowmeter suppliers are working to increase accuracy and provide a broader application base. Going forward, look for more innovations in thermal flowmeter technology, as suppliers continue to respond to end-user needs for reliable and cost-effective ways to measure gas flow.



Dr. Jesse Yoder is a regular contributor to Flow Control *magazine. The president of Flow Research Inc., Dr. Yoder has been a leading analyst in the process control industry since 1986. He has written over 40 market studies and is currently completing a 12-volume series of studies on the worldwide flowmeter market. Included in this series is* The World Market for Pressure Transmitters, *which was published in January 2004 and covers all pressure-related technologies on the market today. Flow Research (*www.flowresearch.com*) offers a quarterly update service called the Worldflow Monitoring Service. You can contact Dr. Yoder by phone at 781 245-3200 or by e-mail at* jesse@flowresearch.com.

EDITOR'S NOTE: The preceding article was developed out of a series of interviews by Dr. Jesse Yoder with pioneers of instrumentation. The purpose of these interviews was to document the history and development of flowmeter technologies. Interviews with Dr. John Olin (Sierra Instruments), Dr. Jerry Kurz (Kurz Instruments), and with Mac McQueen and Bob Deane (FCI) served as the basis for this article.