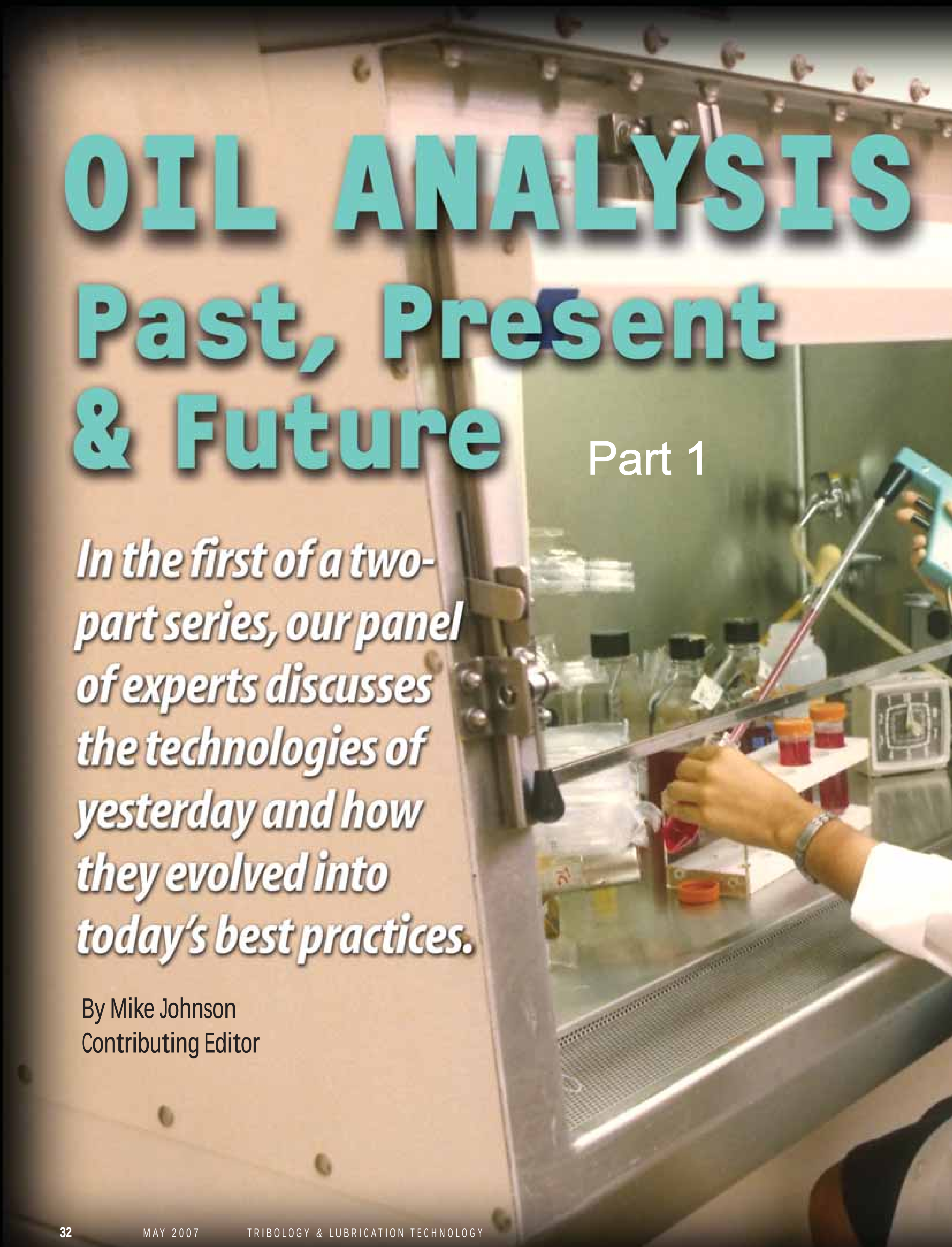
OIL ANALYSIS Past, Present & Future

Part 1



In the first of a two-part series, our panel of experts discusses the technologies of yesterday and how they evolved into today's best practices.

By Mike Johnson
Contributing Editor

Systematic oil analysis began in the late 1940s with the railways. The early applications were oriented toward avoiding catastrophic and costly failures of engines in operation. Success in rail engines prompted the U.S. Navy to begin experimenting with used oil analysis on ships and aircraft engines in the 1950s. Additional successes by the Navy motivated the U.S. Army to begin using this form of analysis in the 1960s, and it was at this point that the fledgling field of oil analysis began to resemble a career path.

The state of oil analysis technology from those early years pales in comparison to the current state of technology. Analytical techniques that today are quickly conducted with a high degree of automation, such as spectroscopy for wear metals, were a laborious and time-consuming—but nevertheless revolutionary—development when first introduced in the early 1960s. Radical changes have occurred in both how tests are conducted and in the nature of the tests themselves. Infrared spectroscopy and wear debris physical analysis are two of many new technologies that have been developed in the last 40 years to the benefit of all equipment owners and analysis practitioners.

Part 1 of this two-part panel presentation provides insights from six industry pioneers as they describe some of the changes they have seen and present their thoughts on the differences in the state of technology from the early years through to the present. In next month's portion, these same practitioners provide a brief look forward to changes that they expect to see in the next 20 years.

To prepare for these articles, TLT conducted a survey of STLE members on trends they expect to see emerge in oil analysis. More than 170 members responded, and those results also will be summarized in next month's article.

To begin, let's introduce our panel of experts:

'At that time [1973] the state-of-the-art for physical properties testing for diesel engine oils was a series of five different test stations operated by several different technicians.'

Daniel P. Anderson began his tribology career with The Foxboro Co. in 1977 working as lab manager in the ferrography product group. In 1982 he published the industry's (still) primary reference on ferrography, *The Wear Particle Atlas* (revised). In 1984 Dan became lab manager for start-up Predict Technologies. He joined Spectro in Littleton, Mass., in 1986 and now is the company's vice president of sales. Along the way Dan developed the Rotrode Filter Spectroscopy, co-founded National Tribology Services and traveled the world promoting instrumentation and turnkey PDM (predictive maintenance) oil analysis laboratories.

Ray Garvey entered the oil analysis field as an officer in the Army Corps of Engineers in 1975 and continued in the data-user role until 1980. From 1991 until now Ray has helped Emerson Process Management/Machinery Health Management (formerly known as CSI) develop a new generation of minilab instruments used for comprehensive on-site industrial oil analysis. Minilab products Ray has helped develop include the Oil View® analyzer, digital viscometer, particle counter and LIMS software, all of which are used in hundreds of power, paper, chemical and manufacturing plants worldwide.

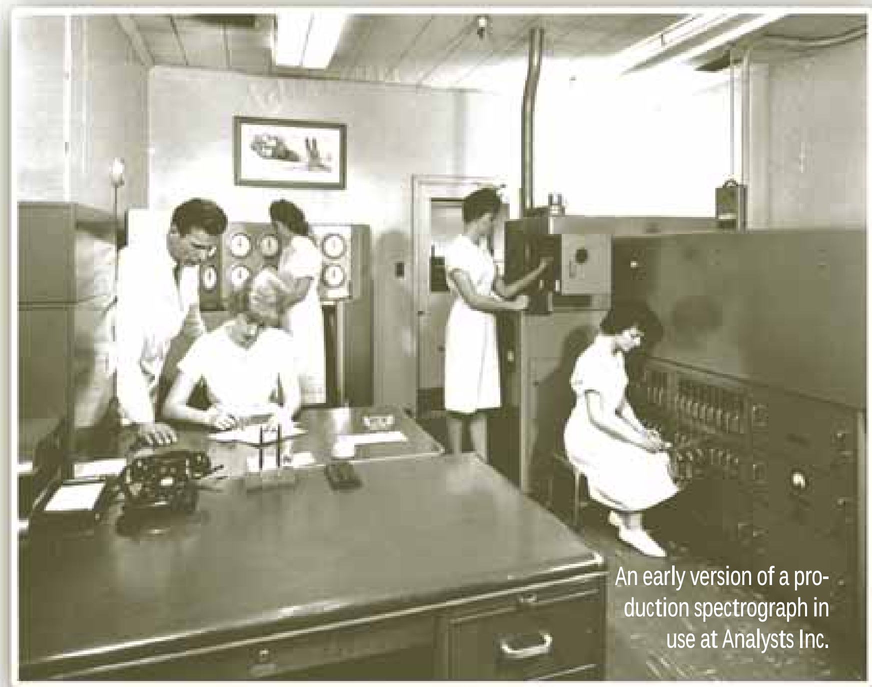
Bill Herguth began his oil analysis career in the early 1970s operating instruments and tabulating data. In 1980 he co-founded Herguth Laboratories, Inc., in Vallejo, Calif., to address fundamental problems in the availability of high quality, sophisticated analysis in the areas of lubrication analysis, equipment condition monitoring and rapid solutions to tribological problems. Bill is CEO of Herguth Laboratories, Inc.

Describe how you became involved in oil analysis and what you recall of the state-of-the-art for instrumentation in the early days.

Jack Poley: I've been in the oil analysis industry since 1961-62. I worked as a chemist/technician for (at that time) the only commercial lab with an emission spectrometer.

This instrument was three meters long, semiautomated with precision electro-mechanical readout "clocks" mounted in a remote console. At that time it determined up to 20 wear, contaminant and additive metals simultaneously.

Each element of interest had a dedicated clock. Each clock face was metal with a replaceable thin cardboard circle on top. Calibration values in parts per million were hand printed so that the clock could be "read" and the value recorded manually, based on where the hands stopped at the end of the readout cycle.



An early version of a production spectrograph in use at Analysts Inc.

(Photo courtesy of Bill Herguth, Herguth Laboratories Inc.)

The whole process took about two minutes, which was a major improvement from existing spectroscopy methods of the day. The biggest problem in operating this instrument was keeping relay contacts in the clock and other mechanisms burnished, lest they malfunction.

Other analytical methods, such as BN, AN, diesel fuel soot (solids), cursory water and viscosity, were available. With the exception of the fuel soot (solids–centrifuge), all were one-test-at-a-time manual processes.

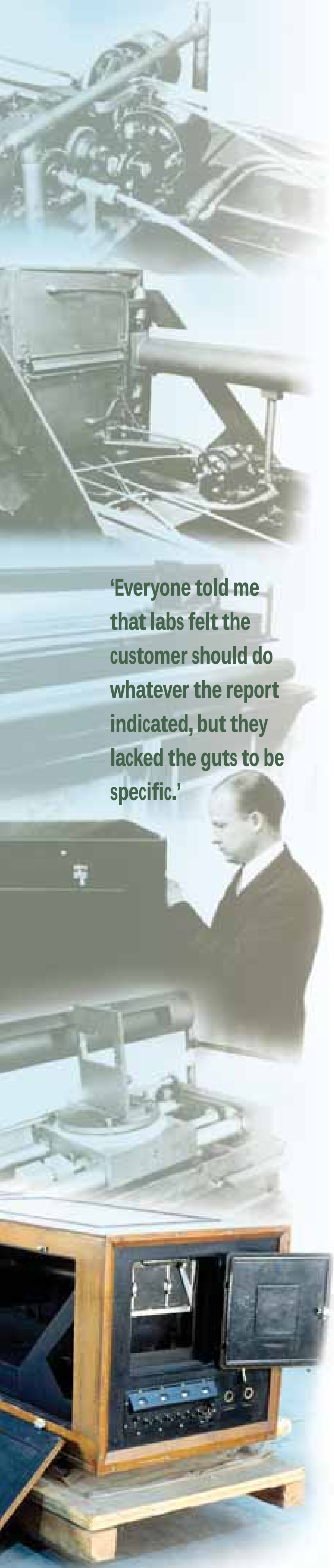
Shirley Mingus: I first became involved in oil analysis in the mid-60s through Analysts Inc. in Oakland Calif. I started in billing and logging samples and went from there to data interpretation. I transferred to the new Stafford, Texas, facility in the early '70s and assumed responsibility for sales and service, eventually became lab manager and later was involved at a senior level in technical services and marketing.

In the '60s most companies (although not many) involved in oil analysis used either an Atomic Absorption Spectrometer (AA), or an Atomic Emission Spectrometer (AE). AA had a limited number of metals; AE had enough metals but was an analog system. If either type of instrument was standardized properly, one would get reasonably good data.

Shirley Mingus began her oil analysis career in the mid-1960s through Analysts, Inc. She moved to Texas to open and run their new lab in the early 1970s and eventually became lab manager. In the mid-70s she joined Lubricon as vice president of technical services and marketing to pursue the possibilities of developing a PDM concept and remained vice president until she retired in 1997. Following Lubricon, Shirley was a consultant to Polaris in the final years of her career. Shirley is now the certified librarian for her town library.

Don Pirro was introduced to oil analysis as an intern lab technician in a laboratory analyzing fuel, crude oil and lubricating oils. He started working full-time for Mobil as a field engineer in 1979, providing assistance and training for new customer oil analysis programs (Mobil EM/PA). In the mid-1990s Don assumed responsibility for Mobil's U.S. Used Oil Analysis programs. Don is EM's global technical advisor for used oil analysis and co-author of the *Lubrication Fundamentals Second Edition* textbook.

Jack Poley began his oil analysis career in the early 1960s with Analysts, Inc. He later founded and was CEO of Lubricon (acquired by Cummins Engine Co. (Fleetguard Division) and then CTC Analytical (now Staveley Services)). He also founded Condition Monitoring International (CMI) and is the current CEO. Jack also writes a bimonthly column on condition monitoring for TLT.



Fuel dilution was performed on a modified gas chromatograph; viscosity and neutralization numbers were performed much as they are today. A particle count required a sized grid, a microscope and someone with very good eyes. A report was generated by hand with a typewriter, and a data analyst interpreted the data with alpha numeric codes. The reports then were copied and mailed, with critical reports phoned. I believe the quality was the best that was possible based on the conditions of that time.

Bill Herguth: My career began in 1973. At that time the state-of-the-art for physical properties testing for diesel engine oils was a series of five different test stations operated by several different technicians. The test suite was usually fuel dilution, solids, water, viscosity and base number. So there were lots of gas chromatographs for fuel, hot plates for water, centrifuges for solids, manual viscometers and titrators.

'Everyone told me that labs felt the customer should do whatever the report indicated, but they lacked the guts to be specific.'

The biggest struggle was in managing large amounts of data manually. We actually evaluated oil sample data from a hard unit card on which the technician wrote in the test results relevant to the subject unit and sample. These cards were pulled from a file cabinet when the customer's samples were logged in and were sent to the lab along with the samples. Then they were passed on to the evaluator for handwritten analysis. These in turn were copied, mailed and refiled for the next time the same unit was sampled.

It was relatively easy to discern trends from one sample to the next, but detailed comparisons of large data sets required enormous amounts of time and convoluted calculations. Clearly the biggest change in the art was the introduction of a computer to provide trending and better data analysis.

Don Pirro: I began work in oil analysis in the mid-1970s as a summer intern working in a fuels laboratory analyzing crude lubricating and fuel oils. I started working for Mobil in 1979 as a field engineer supporting the oil analysis program (Mobil EM/PA) by providing training and assisting customers with analysis interpretation and troubleshooting.

In the early days used oil analysis was used by many customers as a go/no-go criteria with which to make a decision on whether to change out oil (more of the industrial applications) or as a means of identifying major contaminants (ex. glycol, fuel dilution, dirt, water) so as to fix the cause before engine or machine failure occurred. There was less general knowledge about oil analysis, and we often needed to convince and train the customer as to its value, purpose and use. It was uncommon in those days to use oil analysis as a preventive maintenance tool, to look at trends, to gauge the cleanliness of a system or to do significant data analysis.

Ray Garvey: I was a user of oil analysis services under the Army Oil Analysis program between 1975 and 1980. As an Army Oil Analysis Program user it was all about readiness. We had to know our equipment was ready (or not) to be deployed from Fort Hood to any location in the world. In the 1970s the labs used spectrometers extensively. The Department of Defense implemented oil analysis in a big way, primarily using spectrometry.

Industrial oil analysis has been my focus since 1991. The biggest challenges for industrial oil analysis have been the cost-effective and practical uses of particle counting and wear debris analysis to monitor contamination and machinery health issues. Unfortunately these very important tests are often neglected.

Dan Anderson: I sort of fell into oil analysis by virtue of a job switch in 1977. I had spent seven years as an aerosol instrumentation engineer, but the pay wasn't so good so I interviewed with The Foxboro Co. and got a job working for Rod Bowen and Vernon Westcott in their nascent ferrography lab.

We were much enthused because we had a technology that keyed on larger wear particles, those that indicated a transition from normal to abnormal wear. At the time spectrometers were missing certain failures. That is still true today, although spectrometers do very well for reciprocating engines and many other types of equipment.

What did your customers think about the usefulness of oil analysis data in the early years?

Shirley Mingus: Once I was able to go into the field, I discovered a couple of facts quickly. First, up to this point in time sales-people sold oil samples. Secondly, everyone I talked to believed that oil analysis had a place in maintenance, but it was up to the labs to figure out what that place was to be.

Everyone told me that labs felt the customer should do whatever the report indicated, but they lacked the guts to be specific. Some also indicated that when they asked a question of the lab they never got a definitive answer. Conversations with the lab always countered this but not with solutions.

It became clear that we would not get past this roadblock until we made a concerted effort to learn about the customer's equipment and maintenance philosophy and began selling value to the customer. In turn, we had to be prepared to teach customers what would be required to make oil analysis work.

We had a customer with a lot of natural gas integral engines/compressors. One particular group of Cooper engines was showing water in every single sample. The oil was reaching a point of no return, and I was convinced there would be serious failures. The general rule with this equipment was to sweeten the system rather than changing oil due to the volume of oil involved. I visited the site and was told that these engines had always had water and still kept running, so I should leave and not worry about it. I called Cooper and explained that we looked at many of this particular model, and this group was the only group showing water and an alarming acid increase.

The tech rep suggested that I find out if at some time they had removed the drip tubes, which were designed to keep water away from the pistons. Sure enough, that was the problem. The customer's "thank you" was in the form of the good samples received every 60 days.

Jack Poley: The metaphor of oil analysis, as employed to monitor component condition or wear, started just prior to 1950 by the railroad industry in an effort to mitigate complete failures in diesel engines. The desire to prevent catastrophic failures was the main driver for this development. There may have been simultaneous R&D occurring, but this was not the focus.

Beginning at your point of full-time employment in the industry, what do you recall to be milestones in either instrument or methods developments that made a big difference in your business?

Jack Poley: If you started at the beginning of the '60s, as I did, there's only one answer: the automatic emission spectrometer.

Walter Baird's simultaneous-reading spectrometer, using photo electronics to replace tedious spectrum analysis via 35-mm film, was a remarkable breakthrough. This technological development enabled a simultaneous geometric reduction in

'It was uncommon in those days to use oil analysis as a preventive maintenance tool, to look at trends, to gauge the cleanliness of a system or to do significant data analysis.'

the cost of analysis and an increase in output from no more than a dozen analyses in a day to hundreds. The Baird achievement enabled the monitoring of both machine wear and oil condition on a routine basis vs. only oil condition.

The automated spectrometer spawned the modern oil analysis industry. Yes, people looked at filters and strainers and rubbed the oil between their fingers, but there was a distinct lack of science and lots of inconsistency and limitations in such activity. By the time one could actually see evidence of problems in the oil, it was too late to take evasive action. Despite its inherent limitations in analyzing large particles, the automated spectrometer was a pivotal development.

Bill Herguth: One instrument that made a significant contribution in the late 1980s to the cost, speed and reliability of physical properties testing was the Fourier Transform Infrared Spectrophotometer (FTIR). Prior to the FTIR, the physical properties of oil samples were all done with different instruments and people. Investigations required a 30-minute dispersive infrared scan, and all you ended up with was a strip chart trace. The FTIR analysis takes only seconds and is computer-based for comparisons and data manipulation. With the FTIR, and the libraries of spectra, detailed failure investigation could be conducted quickly and economically.

Also, in the old days (pre-automation and computers) you could tell which technician was operating a specific station simply by looking at the bias in the QC data. It was not that the data was out of control but, rather, that each technician had a bias in their results. Today the statistical process control (QC sample data) is almost straight lined. In our lab everything that can be automated is automated. This has done wonders for quality control. In the future, I expect to see more miniaturization and the FTIR taking an even bigger role in the analysis.

Shirley Mingus: All of the instruments have evolved for the better, but I believe the biggest and best improvement by far hasn't occurred because of an instrument change. The introduction of the computer has saved time, reduced errors and improved quality in all of the support services in the lab, (logging, data entry, billing, customer service, etc.).

Best of all, computers can do what oil analysis was meant to do, develop true trend analysis, and eventually provide enough history to truly predict what may happen and when it may happen. I had to do trend analysis manually for years, and I truly appreciate what a computer can do.

Dan Anderson: I would also say that the biggest improvement has been the transition from the slide rule generation to digital computing so that tons of data can be efficiently generated and subsequently stored in databases for historical trending and failure prediction.

As it pertains to analysis instrumentation, the development of ferrography opened a whole new window to oil analysis. In addition to FTIR, which Bill noted, two other big areas of technical innovation included Laser Net Fines for particle shape recognition and advanced methods for large particle detection such as rotrode filter spectroscopy and particle counting. The routine availability of scanning electron microscopy with energy dispersive X-ray analysis also has been a helpful development.

Don Pirro: There really is no comparison in the technology that was available 25 years ago, when used oil analysis was in its infancy, to what is available today. The knowledge gained over these years has helped spur new test methods and techniques that are tailored for used oil analysis. One of the greatest opportunities for cost-effective improvements in instrumentation lies with automation that will reduce test cycle times and, ultimately, cost.

Ray Garvey: In the 1970s I was very impressed by the capabilities of spectroscopy, which provides a tremendous insight into machinery health for mobile equipment, especially engines. Since then I have been impressed by particle measurement systems, including ferrography and other wear debris analysis measurement techniques and by the various particle characterization techniques. I find the instruments that measure ferrous debris larger than 5 microns, like Direct Read ferrography, Particle Quantifier, Oil View®, and MetalScan®, to be intriguing. However, the biggest issue is in work process.

The challenge to the equipment owner is using oil analysis information to impact maintenance. Ownership of the process is the key. If the plant doesn't really own the process, it won't work.

Second, improvement in instrument practicality and ease of use has helped. Third, an improved understanding of the correlation between how machines fail and how the instrument identifies failure has improved the value of the process. **<<**

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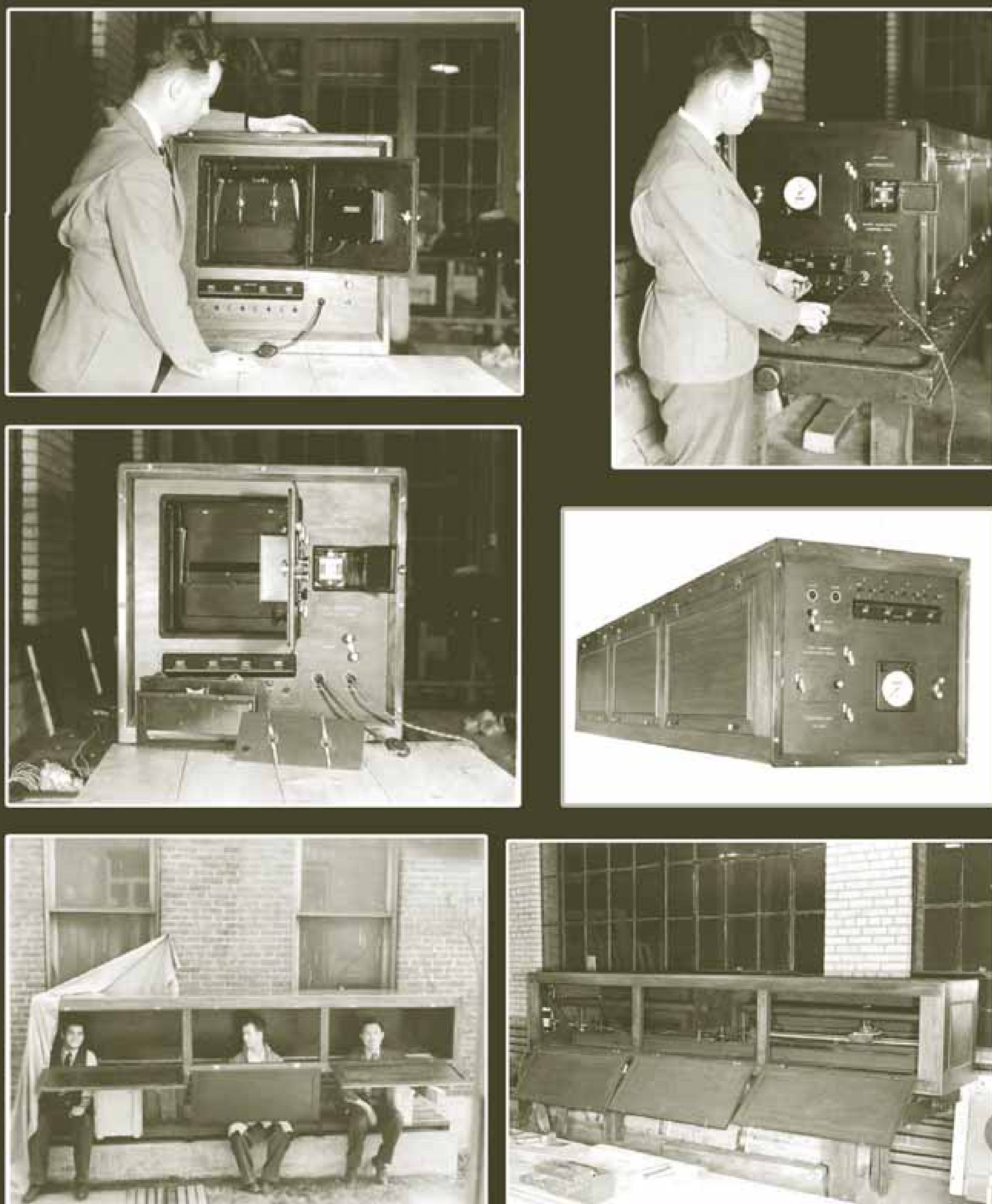

Pictures of the original Baird Spectrographs.

(Photos courtesy of professor Davis Baird, University of South Carolina)