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familiar to a generation of hematology laboratory analysts. The Coulter Counter, which measures particles in the range 0.3 to 1600 micrometers, costs from $16,800 to $30,300, depending on options. This year, Coulter is also offering a microcomputer data system programmed specifically for particle analysis for $6800.

Finally, Micromeritics displayed a prototype of a quite different sort of particle-measuring instrument that the company calls a hydrodynamic chromatograph. The machine is based on a concept developed by Hamish Small of Dow Chemical Company. Like a chromatograph, the instrument has a column stuffed with a nonporous packing. In the column, large particles tend to flow through the center and emerge early, whereas small particles gravitate toward the edge, are retarded, and emerge late. An ultraviolet detector senses the emerging particles. The instrument, designed to handle a wide variety of materials consisting of particles from less than 250 angstroms up to 1 micrometer, is computerized with operating programs residing on floppy disks. A data terminal is also included in the $47,500 price tag that is expected when deliveries begin next year.—ARTHUR L. ROBINSON

New Ways to Measure SO_2 Remotely

Remote measurement of pollutant concentration is a problem of continuing interest to environmental authorities, who frequently are not able either to gain access to industrial facilities or to install monitoring devices on tall smokestacks. Two new devices make it possible to measure the concentration of one important pollutant, sulfur dioxide, in the smokestack plume without ever setting foot inside the factory.

The first is a laser-based instrument developed at SRI International of Menlo Park, California, by a team headed by James Hawley. The instrument is a differential absorption lidar, or DIAL for short; lidar stands for light detection and ranging. The heart of the instrument is a pair of ultraviolet lasers operating at wavelengths in the region of 3000 angstroms. The primary laser operates at a wavelength where sulfur dioxide has a strong absorption band; the second operates at a wavelength 5 angstroms from the first, where sulfur dioxide absorbs only weakly. Each laser is pulsed independently, and the amount of light scattered back toward the laser by the atmosphere is measured with a sensitive detector. Since absorption of light by sulfur dioxide reduces the amount scattered back to the detector, the difference in intensity between the sample and reference beams is proportional to the concentration of the pollutant. The ranging capability of the instrument, which measures the time elapsed between emission of light by the laser and the return of light to the detector, makes it possible to determine the concentration of sulfur dioxide at various points within the plume.

James Hawley
of SRI uses a small laser to aim DIAL at a precise portion of a smokestack plume.

The sensitivity of DIAL is about 2 parts per million·meters (ppm·m) for a 2-minute integration; that means that if a smokestack plume is 10 meters in diameter, the instrument can detect a concentration of 200 parts per billion. Actual concentrations of sulfur dioxide in emissions are generally much higher. Measurements can be obtained when the device is as far as 3 kilometers from the smokestack. If used to make measurements over larger areas, the instrument can also, for example, produce data on the distribution of pollutant gases trapped in temperature inversions.

DIAL is mounted on a 12-meter-long trailer and is powered by a mobile generator. The SRI group recently towed DIAL to Springfield, Illinois, to monitor emissions from the Commonwealth Edison Company's Kincaid Generating Station where they observed a good correlation between concentrations measured with DIAL and those obtained from instruments attached directly to the stacks. But DIAL also obtained information about the dispersal of the plume that otherwise could have been obtained only with a very large number of ground-based air-sampling stations. The instrument has also been used in California to measure emissions from an oil refinery and from several gas- and oil-fired power plants.

The present device, which cost more than $200,000 to construct, is used to perform contract monitoring services for utilities, regulatory agencies, and other groups. If the demand for such service is strong enough, adds Hawley, one or more additional devices could be constructed.

The second new instrument, displayed for the first time at the Pittsburgh Conference, is, at $32,700, much less expensive, but it is also less versatile. Called the Visiplume 121, the device depends on technology originally developed at the NASA–Langley Research Center by Reginald J. Exton and Raymond Gregory. They subsequently left NASA and founded Research Ventures, Inc., of Williamsburg, Virginia, to commercialize the device. Much of the correlation technology used in the instrument was provided by Langley-Ford Instruments of Amherst, Massachusetts, and both companies now sell it.

Visiplume is also based on ultraviolet absorption measurements near 3000 angstroms but it uses the sun as its light

The Visiplume 121

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source. In this case, the core of the system is an ultraviolet-sensitive television camera that visualizes the plume by observing the absorption of sulfur dioxide against the ultraviolet sky. Sulfur dioxide concentrations are obtained by focusing the instrument on a particular part of the plume and measuring the difference in absorption at two wavelengths. Atmospheric effects can be compensated for by measuring the absorption of light at the same wavelengths when the camera is focused outside the plume. The device does not have any ranging capability, and therefore the concentration obtained is the total concentration along the device's optical pathlength.

The Visiplume also has the capability to determine effluent velocity by tracking fluctuations in the sulfur dioxide concentration as they move downstream. These fluctuations are actually large eddies that are produced at the stack lip as the flow mixes with ambient air. The correlation unit in the spectrometer determines the average distance moved by the fluctuations in a given time interval. If the size of the stack opening is known, the sulfur dioxide emission rate can be determined by multiplying the average concentration by the velocity. The entire process is controlled by a microprocessor, and results can be displayed directly on the television screen or printed out for a permanent record.

The Visiplume has a maximum sensitivity of 50 ppm·m, and an effective range of about 500 to 600 meters under normal atmospheric conditions. It can monitor emission rates varying from 4 to 70 meters per second.—THOMAS H. MAUGH II

At $100 per Hour, Service Is a Big Concern

Like the rest of us, the instrument repairman is now paying more for gasoline, air travel, hotel rooms, and interest on his stock of repair parts—to the point where service calls now run between $85 and $100 per hour. Concerned by this increased cost, both instrument makers and users have been seeking new ways to reduce the need for service calls. Their ability to do this has been greatly abetted by the proliferation of microprocessors in even the least expensive analytical instruments.

The incorporation of a microprocessor and appropriate programming into a spectrophotometer, for example, makes it possible for the instrument to tell the user something as simple as "The source is not operating" or "The detector is inoperative," or something more complicated such as "The power supply is malfunctioning."

On some more sophisticated instruments, the problem can even be localized to a specific circuit board. The Du-Pont Company's 1090 thermal analyzer, for example, goes through an intricate testing sequence each time it is turned on to ensure that each circuit board and subcomponent is operating properly. Key-operated tests exercise specific areas of the electronics more extensively to pinpoint problems. In many cases, the defective circuit board can simply be replaced without having a service call. This type of self-diagnosis is rare now, but promises to become more common.

Taking the microprocessor one step further, certain mass spectrometers made by the Finnigan Corporation, for example, and some computers manufactured by Hewlett-Packard Company are available with a Modem that permits the instrument to be linked by telephone with diagnostic equipment at the factory for precise analysis of the problem. For certain types of instruments, self-diagnosis by the instrument or a call to the company can solve 90 percent of service problems.

Once the problem is diagnosed, there are several approaches to eliminating it. Perhaps the newest approach for analytical instruments is user serviceability. Beckman Instruments, Inc., for example, this year introduced a line of instruments—including ultraviolet and infrared spectrophotometers and *p*H meters—in which most repairs can be made with a screwdriver.

Beckman also markets what it terms Rapid Kits for each of these instruments. These kits sell for about a third of the price of the instrument itself and contain a collection of the most frequently replaced parts. A Rapid Kit for one infrared spectrophotometer, for instance, contains a keyboard, the printer, a circuit board that controls both, the sample assembly, the source, and another circuit board that is the power supply—parts, says Nathaniel Brenner of Beckman, that account for 95 percent of all failures on such an instrument. The user simply replaces a defective part with the new one and mails the old part back to the factory for replacement. Whether analytical chemists will be sufficiently eager for immediate instrument repair to invest a substantial fraction of the purchase price in spare parts remains to be seen.

A more common trend in both universities and industry is to have electronic technicians whose sole job is to perform maintenance on a number of instruments. This has, of course, been going on for some time, but manufacturers have become both more cognizant and more appreciative of the effort. Most major firms now offer 1- or 2-week training courses for these technicians to familiarize them with the instrument and servicing peculiarities.

Other companies, such as the Perkin-Elmer Corporation, are putting increased emphasis on preventive maintenance plans as a way to reduce service costs. Since travel, food, and lodging costs are reduced when several instruments at one location are serviced on one visit, total costs are reduced. A preventive maintenance plan, which includes two scheduled maintenance calls per year, costs between 5 and 7 percent of the initial cost of the instrument at Perkin-Elmer, whereas a full-protection plan that includes emergency service costs 9 to 12 percent of the purchase price.

A few companies are also consolidating their parts inventories to reduce the burden of financing large inventories at high interest rates. Varian Instrument Group, for example, has closed its regional parts centers and consolidated its inventory in the main facility at Sunnyvale, California. "With Federal Express and other couriers," says a spokesman, "we can provide overnight service to anywhere in the country from this one location, so the customer is not really losing any convenience."

No matter how well built they are, instruments are going to break down occasionally. As they become more sophisticated and complicated, the possibility of malfunction increases. Most of these new approaches to service are not going to prevent breakdowns. They may, however, make them a lot less painful.

—THOMAS H. MAUGH II

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