distributing reagents, diluting samples, dispensing them, washing test tubes, and so on. Timing and sequence of events is completely user programmable. Hence it is possible to have automated preparation of various sample types at one sitting. Prices range from about $6600 for the Gilson 212B liquids handler with a built-in computer controller to just over $24,400 for the Hamilton Microlab 2000 with an IBM PC*jr*. computer.

Finally, Varian and Perkin-Elmer introduced autosamplers with robot arms. The arms allow user-programmable selection of samples in any order rather than in sequence from a rotating carousel. Varian's ASM (Automatic Sample Manager) 100, designed for the company's XL series of nuclear magnetic resonance spectrometers, has an internal microcomputer controller and can accommodate temperature-controllable trays of up to 100 samples. Among the interesting features is a test for the presence of a sample. If none is found in the designated location, an error message is sent to the computer overseeing spectrometer operation. Cost is $30,000. Perkin-Elmer's DSC-4 Robotic System allows unattended analysis of up to 48 samples in the company's TADS series of thermal analysis systems. Its cost is $14,500.—**ARTHUR L. ROBINSON**

A New Trend: Training on "the Tube"

A generation of young scientists who were raised on "Sesame Street" and "The Electric Company" and received at least part of their formal education through the use of instructional videocassettes may soon also be learning about instrument maintenance and usage through television. "There is a cadre of scientists out there who are all primed to use television to learn how to use and repair complicated instruments," says one media consultant. "The analytical instrument industry has been exceptionally lax in failing to provide for them. Videocassettes have so many advantages over a conventional instruction manual that it is virtually a crime for companies not to be using them."

That situation is changing, however. Three companies at the Pittsburgh Conference were actively promoting videocassettes and at least two more companies are using them in a more low-key manner. If these companies' efforts prove successful, says the consultant, "videocassettes may sweep through the industry."

One company in the forefront of the videocassette revolution is Finnigan MAT (San Jose, California), the largest manufacturer of mass spectrometers. The company has long played an active role in training MS users through its Finnigan MAT Institute in Cincinnati, which has trained more than 5000 individuals in 1-week courses since 1978. Finnigan's entry into videocassettes was catalyzed by the introduction 2 years ago (*Science*, 8 April 1983, p. 178) of its Ion Trap Detector, an inexpensive quadrupole MS designed as a detector for gas chromatography (GC).

"The people who buy one of our sophisticated mass spectrometers are eager to come to Cincinnati for a week to learn how to use it," says Don DeJongh of Finnigan, "but the ones who buy a $32,000 detector for a GC aren't willing to spend either the time or the money. We decided we had to find a better—and cheaper—way to reach them. The videocassette looked to us to be the ideal way to do it."

It is, perhaps, ironic then that Finnigan's first two videocassettes to reach the market are directed toward users of large instruments. Both describe preventive maintenance on Finnigan's 1020/OWA GC/MS/DS (GC/mass spectrometer/data system). One shows how to clean the ion source and related assemblies of the MS, and the second shows how to clean the quadrupole rods. The key word in both cases is "shows." "It's virtually impossible to learn these techniques from an instruction manual," says DeJongh, "but the cassettes lead you through them in step-by-step fashion so that it is easy to see exactly what is being done." One important advantage of the cassettes, he notes, is that all technicians who view it receive the same training; that is not necessarily the case when one individual in a laboratory trains another, who might then train a third.

The cassettes come with a manual containing the script for individuals who have difficulties with English. The packages will eventually also be available in other languages. Training cassettes for the Ion Trap Detector will be available later this year, and cassettes for other instruments are being planned.

EM Science (Cherry Hill, New Jersey) displayed a cassette designed for Hitachi HPLC's. The three-part cassette covers installation, operation, and troubleshooting for isocratic HPLC's, says Gene Desotelle of EM, and a companion cassette for gradient instruments is in preparation. The latter cassette is taking more time to prepare, he says, because the gradient systems are more complex and it is necessary to cover programming of the computers. EM has been using videocassettes for several years to train distributors and to demonstrate instrument capabilities for potential purchasers, he adds, and the extension to user training came naturally.

Varian Associates, Inc. (Palo Alto), did not display videocassettes at the conference, but the company has been using them for 2 years for analytical instruments and even longer for their other electronic products. The company now markets six tapes covering the operation of data systems, use and maintenance of GC's and LC's, and general principles of HPLC. Sales of the cassettes have gotten off to "a slow start," says Hal Hartman of Varian; "I thought it would go faster." He is optimistic about future sales, however, because of recent decreases in the price of videocassette recorders. "When VCR's dropped below $500," he says, "they became a petty-cash item, and I think more labs are now willing to purchase them."

A somewhat different approach to video is the production of cassettes that are oriented toward techniques rather than specific instruments. The American Chemical Society, for example, has been marketing such courses for 5 years. The courses, which include two to six cassettes apiece, cover such topics as gas chromatography, interpretation of infrared spectroscopy, toxicology, chemical engineering for chemistry, technical writing, and molecular reactivity (kinetics and thermodynamics). These courses can be rented for $200 to $400 per week or purchased for $720 to $1800. The society is not now preparing any new courses, says Harry Walsh, because sales have not been high enough to allow the program to be self-sustaining. Walsh is optimistic that sales will increase, however, and that new programs can be prepared in the future.

LC Resources Inc. (San Jose) introduced a new cassette series on principles

of HPLC at the conference. The five cassettes in the series cover theory, the different types of equipment available, optimization of separations, analysis of results, and other topics. Also available are a manual and an instructor's guide. The complete course costs $1250. A companion course on gas chromatography is expected to be available within the year.

The cassettes oriented toward specific instruments are relatively expensive compared to commercial cassettes. Finnigan's cost $250 apiece, Varian's are $195, and EM's are $150. The cassettes are not included in the purchase price of the instruments in the United States, companies say, because price competition is too great. In the future, says DeJongh, they will probably be included in the package for sales abroad because service is a greater problem there. Shipments to developing countries, he adds, may even include a videocassette player to induce the user to perform more preventive maintenance. "For customers in relatively isolated areas," he concludes, "anything they can do to prevent the need for service calls is a benefit for both them and us."—**THOMAS H. MAUGH II**

A New Dimension in Gas Chromatography

Gas chromatography (GC) has undergone a renaissance during the last 5 years as a result of the introduction of reliable capillary techniques. These techniques make gas chromatograms highly reproducible—to the point where retention times can be used for analysis of unknowns—and have permitted unprecedented separations. Nonetheless, the separation of complex mixtures is still often a problem because two or more components of such a mixture will often have similar retention times on a given column. Most of these separation problems can be solved with a new technique known as multidimensional GC or MDGC.

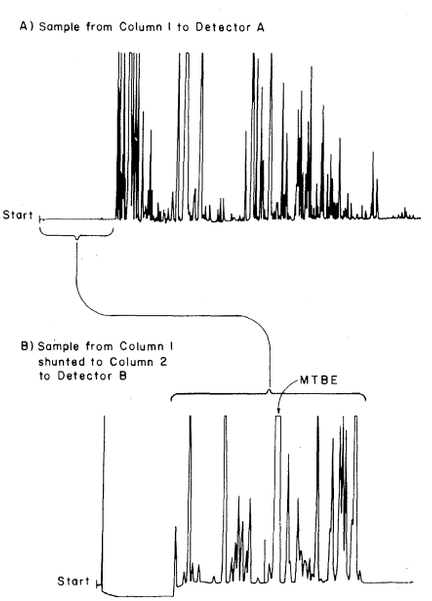
In essence, MDGC involves the use of two or more separate GC columns for a given separation; ideally, each column will reside in its own oven so that its temperature can be controlled independently. Most often, the second column will have a markedly different polarity from that of the first column to enhance separation of components that are not separated cleanly in the first column.

The two columns can be connected serially to provide increased separations, but the most common application is column switching for heartcutting. In this case, most of the sample eluted from the first column goes directly to a detector, but an inadequately resolved fraction is shunted to the second column for more complete separation. This approach is especially useful for the analysis of a trace component in a complex mixture or a minor component eluting immediately after a major component. MDGC can thus sharply reduce the time required for analysis of specific components in complex mixtures and can often provide separations that are impossible with other techniques.

MDGC was originally conceived in the mid-1960's by David Deans of ICI Ltd. in England, but it did not receive much attention until the development of capillary columns in the late 1970's. The technique has subsequently been used to a significant extent in Europe, but is only now generating interest in the United States. Three new instruments for general MDGC were displayed for the first time in the United States at this year's Pittsburgh Conference.

The key to MDGC is the use of special devices to perform the shunting. Shunting can be achieved with a conventional mechanical valve, but such valves typically are large, which means they are slow to equilibrate in the oven, and often have large dead volumes, which degrade resolution. Only recently have acceptably small valves been developed.

Deans developed what is known as a valveless coupling piece, a so-called "live"-switching device. The coupling piece has a small mass and minimal dead volume; most important, the direction of gas flow is controlled by small variations in gas pressure rather than by mechanical devices. The use of a coupling piece gives more sensitive and precise control of heartcutting and other shunting operations and is most valuable when shunting must be performed several times during a particular run. Counterbalancing this flexibility is its increased complexity compared to a mechanical valve.



Heartcutting

Determination of methyl-t-butyl ether (MTBE) in gasoline by heartcutting. To analyze MTBE, all components of the first column that elute before n-heptane are shunted to the second column. [Source: IBM]

A typical application of heartcutting was described at the conference by Susan Sonchik and John Walker of IBM Instruments, Inc. (Danbury, Connecticut). They demonstrated the analysis of the octane enhancer methyl-*t*-butyl ether (MTBE) in gasoline. Gasoline is a very complex mixture of hydrocarbons, and MTBE typically elutes in the same region as many short-branched hydrocarbons. To analyze for MTBE, all components of the mixture that elute before *n*-heptane are shunted to the second column, which is eluted under different conditions to enhance separation (see figure). In this case, the shunted fraction occurs at the beginning of the chromatogram, but it could occur anywhere during the separation.

The remainder of the gasoline components normally flow directly to a detector. Alternatively, analysis time can be shortened by a technique called backflushing, in which the flow of carrier gas through the first column is reversed to remove the heavier components from the column more quickly (since they will be closer to the injection port than to the detector). Backflushing is especially useful for components that would elute only very slowly under normal conditions.

The new instruments displayed at the conference are the GC/9630 from IBM, the Sichromat 2, manufactured by Siemens AG of West Germany and distributed in the United States by ES Industries (Marlton, New Jersey), and the Series 500 from Hach Company (Loveland, Colorado). All three are fully auto-