Lab Equipment, Tools, and Widgets

From syringes to shakers, a cast of thousands makes chemistry the star.

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As most Hollywood stars realize, their fame depends on the combined efforts of all the "little" people—from makeup and hair to set design, film editing, and even the efforts of the best boys and the gaffers. So, too, for the Nobel Prize-winning chemist. It's not just the technicians, the postdocs, the grad students, and the big-ticket instruments and the ancillary equipment—it's the pipettes and pipette tips, the valves and shakers, the microwaves and filters—and the ever-reliable supply houses that sell them all—that make star-quality science possible and the business of the chemical enterprise real.

It's All Wet

Every manner of liquid handling is required in the lab—from volumetric transfer via pipetting and syringes to the most sophisticated autoinjectors. And every kind of company has evolved to try to satisfy the demand for liquid handling.

First, of course, it was the syringe. By the dawn of the 20th century, the Becton Dickinson company was formed, and it produced one of the first all-glass syringes. Maxwell W. Becton and Fairleigh S. Dickinson met on a sales trip in 1897 and went into business together, establishing their medical device import company Becton, Dickinson and Co. For $40, their company acquired a half-interest in the patent rights to an all-glass syringe developed by H. Wulfing Luer of Paris. Although such syringes were designed initially for medical use, they would quickly prove to be of great utility in analytical chemistry.

By the 1950s, the exacting demands of new technologies, such as radioisotopes and modern chromatography, would lead to the production of newer syringes with ever-more-precise specifications. Hamilton (founded in 1953 to produce radiation-shielded syringes), for example, pioneered fine-needled, highly accurate syringes capable of injecting defined gas-sample volumes into the new gas chromatographs, helping to create a new world of quantitative analysis. This Luer-tipped 100-µL syringe was known as the 710 LTN. It was seen as an ideal replacement for the Becton Dickinson syringes, which at the time only came in 250-µL insulin-unit graded volumes.

Companies such as SGE Chromatography Products also came into existence to produce syringes driven by the demand for chromatography accessories, including gas-tight syringes capable of GC injection. Eventually, such syringes would lead to the development of automatic injection pumps for both GC and HPLC. SGE began exclusively as a syringe producer in the late 1960s, founded by Ernest Dawes as Scientific Glass Engineering in a garage in Melbourne, Australia.

But other means of liquid handling, especially in small volumes, were also developed. A good example of this was produced by the Eppendorf Co., founded in 1945. In 1958, the company pioneered the piston-stroke pipette (designed by H. Schnitger at the University of Marburg), which allowed for the efficient and accurate manipulation of microliter volumes. In 1962, Eppendorf began supplying tips and plasticware (including the eponymous Eppendorf tube) that have become staples in the modern molecular biology lab. And in 1978, the company launched the Multipette 4780, leading to a generation of adjustable multipipetting devices for laboratory use. Other companies such as Gilson (founded in the 1940s by a faculty member at the University of Wisconsin Medical School) produce specialized medical electronics and instruments and supply sophisticated pipetting and liquid-handling devices to meet the expanding needs of combinatorial chemistry and molecular biology.

Top: Büchler Instruments Platform Shaker ad, *Analytical Chemistry*, 1968

Center: Hamilton Co. ad, *Analytical Chemistry*, 1960

Sample Prep

But measuring and adding samples in solution are certainly not all that matters. Sample prep is also key—from mixing and shaking, to evaporating, to heating, sonicating, or microwaving. And these are

VENDORS GALORE

Lacking a local 7-Eleven to sell pipettes, test tubes, and balances 24/7, the chemical industry developed the next best thing—the scientific vendor company. Everyone knows their names and has thumbed through their catalogs—companies that collectively would fill the role of a Sears Roebuck for a scattered but developing national, and then international, chemical research industry.

The Arthur H. Thomas Co. was founded in 1900 and produced its first catalog in 1904. The catalog not only contained details of the equipment and supplies offered, but also encyclopedic descriptions of pertinent chemistry, metallurgy, and biology, all written by Thomas himself. In 1983, the company changed its name to Thomas Scientific.

The Scientific Materials Co. (renamed Fisher Scientific Co. in 1926) was founded in Pittsburgh by Chester Garfield Fisher in 1902 to provide the scientific reagents and supplies required by a burgeoning Pennsylvania industry. In 1904, Fisher published its own first *Catalog of Laboratory Apparatus & Supplies*, later renamed *The Fisher Catalog*. In 2001, Fisher acquired Cole-Parmer Instrument Co., thereby adding another laboratory supplier (with another well-known catalog) to its portfolio.

VWR Scientific Products (now VWR International, a subsidiary of Clayton, Dubilier & Rice since 2003) was founded in 1852 by John Taylor as a pharmaceutical and chemical glassware business in Sacramento to serve assayers in the California gold rush. VWR's Sargent-Welch division provides its own catalog, selling to educational institutions.

Above: A. H. Thomas delivery truck ca. 1900, *Made to Measure*, 1999

also often key to the most efficient chemistry—to enhancing chemical reactions (from classic to combinatorial) through heat, concentration, or motion. Over the years, numerous companies have branched out or developed to focus on the various requirements of sample prep, transforming the way chemistry is done. Although today many types of evaporators are on the market, the veteran example is the rotary evaporator, first introduced in 1957 by Walter Büchi, whose Büchi Labortechnik AG was founded in 1939 in Switzerland as a manufacturer of glass instruments. Today's market has grown to include Brinkmann, the Büchi Group, Heidolph, and Labconco.

Chemistry is one field in which getting the shakes is of significant benefit, as witness the long history of shakers and mixers developed to assist in chemical reactions, from the simplest magnetic stir-bar system to the largest multilevel flask shaker. For example, the Christian Eberbach Co., founded in 1843 by a pharmacist in Ann Arbor, MI, started as a laboratory supply and importing business that began manufacturing its own line of lab equipment in the 1880s, leading to the old-standby Eberbach's Rugged Shakers. Other recognizable names in shakers, heaters, and stirrers are Heidolph (founded in Germany 60 years ago), Barnstead (founded in 1878 in Boston), and Thermolyne (founded in 1942 in Dubuque, IA). In 1988, the companies merged to form Barnstead/Thermolyne, which became an Apogent Technologies company (part of Fisher Scientific International since 2004). (Another Apogent subsidiary, Nalge Nunc International, created Nalgene plasticware and those quintessential laboratory wash bottles used by generations of grad students as squirt guns.)

The specialized laboratory microwave is exemplified by CEM Corp., founded in 1978 by chemist Michael J. Collins (whose disseration was on microwave spectroscopy) and two colleagues to produce a moisture/solids analyzer—the first microwave-based laboratory instrument. Microwave-based chemistry has become an important research area, especially in the realm of combinatorial chemistry and drug development. Another example is Biotage AB, created through Pyrosequencing's acquisition of Personal Chemistry and Biotage in 2003. Through its Personal Chemistry group, the company continues its research into microwave-assisted compound development and providing systems for microwave research to individual laboratories.

Waxing Hot

No analytical research laboratory is complete without instruments for thermal analysis and processing. Although hardly "widgets," calorimeters, heating baths, and ovens are a collective analytical miscellany linked by temperature and their frequency of routine use.

Thermal analysis has come a long way from the simple calorimeters first used at the dawn of the 20th century. In 1899, the Standard Calorimeter Co. was founded in Champaign, IL, by S. W. Parr, a professor at the University of Illinois. The company was based on a simplified instrument Parr had developed to measure the heating value of coal. Parr's "calorie meter" (calorimeter) and other fuel-testing devices helped boost the role of thermal analysis, which would continue to grow throughout the century, among a host of other companies.

Modern methods of thermal analysis include differential scanning calorimetry (DSC), temperature-modulated differential scanning calorimetry (TMDSC), and dynamic mechanical analysis (DMA). These and other methods can be used to study the properties and heating behavior of the wide variety of new materials generated by the modern chemical industry. Companies such as Mettler Toledo, MicroCal , Netzsch Instruments, Paar Instrument Co., and TA Instruments are adapting to the demand for these and other forms of thermal analysis. As with Parr, these companies have a varied history. For example, TA Instruments was founded more than 35 years ago. It was originally part of the DuPont company, which developed thermal-analysis instrumentation to aid its polymer researchers.

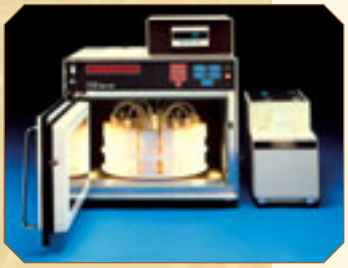
Focus on Filtration

From the simplest folded-paper-in-a-funnel to the most complex solid-phase extraction cartridge, sample processing through filters is key to the chemical enterprise, and vendors have formed to supply and develop a host of alternatives. One of the earliest pioneers in scientific filtration was the Whatman company, born of a paper mill in 1740 in England. By the 20th century, the company was supplying a wide variety of filter papers for scientific purposes. In fact, Whatman No.1 filter paper helped launch the development of paper chromatography, being the medium used by research scientists R. Consden, A. H. Gordon, and Archer J. P. Martin in Leeds in 1944.

Millipore Corp. was founded in 1954, when engineer Jack Bush purchased the rights to the newly developed membrane-production process from his employer, the Lovell Chemical Co. in Watertown, MA. Today, filtration has evolved from the use of loose filter papers to crafted plastic units often containing highly specialized membranes or paper filters. Both Whatman and Millipore, for example, offer presterilized filtration units that make possible many of the standard biotechnology protocols that are the hallmark of modern molecular biology.

Related to filtration, but actually a form of adsorption chromatography, is solid-phase extraction (SPE). Sorbents for SPE are packaged commercially in three basic formats: solid disks, prepared cartridges, and a variety of standard syringe barrels.

From the first use of silica, alumina, Florosil, and kieselguhr in the 1930s as solid adsorbent, to the introduction of the Sep-Pak by Waters in 1978, to the coining of the term "SPE" in 1982 by employees of the J. T. Baker Co., to the present, this technique has become a powerful tool for sample preparation in modern chemistry. Among the many companies involved in SPE today are Supelco, Restek, and Waters.



Above: CEM microwave digestion system, MDS 81, *Made to Measure*, 1999

Life in the Hood

Maintaining a safe, clean, and functional laboratory has always been a critical need for the chemist, whose life, before modern technology, was a shaky balance between successful research and self-poisoning. With the development of specialized hoods, gloves, goggles, and cleaning instruments, the life of the chemist became not only easier but safer.

Fume hoods are ubiquitous in chemical laboratories and are used to exhaust hazardous fumes through a top portal using fans, protecting researchers and lab inhabitants. Such hoods are typical products marketed by laboratory supply and construction companies. For example, Labconco, originally named the Laboratory Construction Co., founded in 1925 by Ralph Callaway and Philip Goldfisch in yet another garage, this time in Kansas City, was an early supplier of standard laboratory fume hoods, along with a product line including laboratory washers and carts. Specialized fume hoods have also been developed for protection against specific chemical hazards, including perchloric acid and radioisotopes, and are manufactured by a wide variety of companies, such as HEMCO, Labconco, and NuAire.

Another such company, Hotpack (now part of SP Industries), was founded more than 90 years ago in Philadelphia to produce a wide variety of laboratory equipment, now extending to glassware washers, laboratory steam sterilizers, environmental rooms, refrigerators and freezers, ovens, incubators, biological safety cabinets and flow hoods, and environmental and stability chambers.

Widgets

Last but not least, the success of the modern laboratory instrument has been founded on the tiniest of components. Not the gratings, or the crystals, or the magnets, or the column packings that spring so quickly to mind—but the simplest valves and fittings, the tubing, the batteries, fuel cells, and generators that collectively are just as critical to making modern laboratory science possible.

Connecting various devices from different manufacturers, or different models from the same manufacturers, is often an art form—requiring the appropriate valves, fittings, and tubing. This is especially the case in HPLC, where pressure and connectivity issues can be exceedingly complex. For these and other instruments, companies such as Alltech (founded in 1970), Rheodyne, Swagelock, Upchurch, and VICI (Valco Instrument Co., Inc., founded in 1973) provide the appropriate connectors for their own and other product accessories to enable the kind of flexibility that modern laboratory researchers have come to expect.

Another "widget" that is core to several analytical instruments, especially gas analyzers, and with the potential to power an ever-widening array of sensor devices, is the electrochemical fuel cell. A hydrogen fuel cell works like a battery, using an anode and cathode, with an electrolyte composed of various materials or solutions. Hydrogen flows into the anode, and the molecules are split into protons and electrons. The protons flow through the electrolyte, while the electrons create a usable electrical current. At the other end of the fuel cell, oxygen from air flows into the cathode. The hydrogen protons and electrons reunite in the cathode and bond with the oxygen atoms to form water. An increasing number of companies, such as Proton Energy Systems, Johnson Matthey, and Teledyne, are developing ever-more-efficient fuel cells with the long-term goal of transforming the transportation and other industries. Microfuel cells in particular have tremendous potential for developing portable analytical instruments and miniaturized sensors capable of being used in consumer products, industrial production, and defense.

In the final analysis, it is impossible to ignore the vast array of "minor" devices and services that play such a critical role in the modern laboratory. Although they are provided by companies that are often known primarily as names in a supply catalog or printed on cardboard boxes in lab-bench drawers, these widgets and what-nots are just as important, in their way, as products created by companies that have their names sleekly embossed on the great gray boxes of the major instruments. They are all part and parcel, and necessary partners, of the modern chemical enterprise. ◆