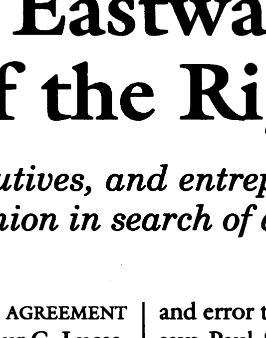
Looking Eastward in Search of the Right Stuff

U.S. scientists, executives, and entrepreneurs are combing the former Soviet Union in search of advanced materials

"WE CAME TO A GENTLEMEN'S AGREEMENT in a bar in Vienna," recalls Arthur C. Lucas. There, during a November 1989 conference on radiation exposure measurement, he and three scientists from what was then the Soviet Union toasted the birth of an arrangement they hoped would grow into a lasting business partnership.

So far, so good, says Lucas 2 years later. This year Lucas, vice president for technology of Victoreen Inc., a Cleveland company that makes radiation dosimetry equipment such as the exposure badges worn by workers in nuclear power plants, expects to import as many as 100,000 radiation-sensitive disks of synthetic sapphire (aluminum oxide) from his partners in the East—Vitaly Gotlieb of the Riga Medical Institute in Latvia and Vsevlold Kortov and Mark Akselrod of the Urals Polytechnic Institute in Sverdlovsk. When doped with carbon atoms, the crystals can monitor radiation levels 40 times fainter than the levels picked up by the lithium fluoride-based materials usually used in the West, Lucas says—a sensitivity that Lucas hopes will make them the standard in the nuclear industry.



Matchmaker. *John Kiser, the founder of Kiser Research Inc.*

KISER RESEARCH INC.

With the raising of the Iron Curtain and the crumbling of the Soviet Union, many more glasses are being clinked to seal agreements aimed at developing materials technologies that were once hidden from Western eyes. Materials scientists, like most researchers in the former Soviet Union, are desperate to strut their stuff to Western observers in order to attract patronage they can no longer get from their government. And they have a lot to offer, Western scientists and entrepreneurs are finding. With limited financial resources for equipment, scientists in Russia and the other former Soviet republics were apt to develop deep theoretical insights into the chemistry and physics underlying material properties. That sets them apart from many of their Western counterparts, who often rely on costly trial and error to develop practical technologies, says Paul Stott, a research manager at the Uniroyal Chemical Co. in Middlebury, Connecticut. Among the results of that research culture: "microreactors" almost small enough for a person to carry yet capable of churning out as much commodity polymer as house-sized reactors, high temperature superconducting powders efficiently manufactured by a technique akin to the burning of a sparkler, and hundreds of others materials and tidbits of engineering know-how.

Such technology is bound to become more familiar to Western researchers and businesses if recently announced high-profile efforts to salvage science in the former Soviet Union succeed. Earlier this month, for example, Representative George Brown (D–CA), chairman of the House Science, Space, and Technology Committee, proposed setting up a $200 million foundation to fund Russian research in areas including materials science. Not long after, Secretary of State James Baker told Russian President Boris Yeltsin that the United States would earmark $25 million to help hook up Russian defense scientists with Western industries. But those initiatives would merely be following paths already pioneered by private firms, academic institutions, and individuals.

Consider E. I. Du Pont de Nemours and Co. A year before Lucas and his Soviet partners raised their glasses, and just about the time that glasnost was becoming entrenched, Du Pont executives traveled from their Wilmington headquarters to the Soviet Union, including faraway places like the Catalyst Institute in Novosibirsk, Siberia. They were searching for "technology that might have commercial potential," says Richard Quisenberry, vice president of the Du Pont Science and Engineering Laboratory. His company soon opened up an office in Moscow to gather scientific intelligence. Some of the results so far: "We now are looking into membranes for [chemical] separation technologies, toughened polyamide resins [such as the Kevlar of bullet proof vests] and better catalysts for making polymers," Quisenberry told *Science*.

And Du Pont isn't alone in doing that kind of reconnaissance. For about a decade, John Kiser and his colleagues at a Washington, D.C.-based firm known as Kiser Research Inc. have been scouting the research laboratories of the former Soviet Union is search of commercially promising technologies. Recently, for example, Kiser began representing a consortium of former Soviet defense scientists called the Urals Center (after the region encompassing many defense research centers). The center's stated aim is to turn its collective scientific and technological expertise to making all manner of materials, including synthetic diamond materials, aerospace ceramics, and superfine metal powders for manufacturing new, more capable alloys. Kiser thinks that some of the pooled expertise is bound to catch eyes in the West, and it is busy letting potential partners know about the work.

When a match between an East Bloc technology and a Western suitor looks promising, Kiser often acts as the marriage broker. The firm sells itself as being able to negotiate sound East-West business arrangements in spite of the thicket of obstacles confronting would-be investors in the former Soviet Union: the lack of a reliable banking system, uncertain protection for intellectual rights, and an absence of guidelines for pricing products and assessing the value of technology.

Kiser's matchmaking skills recently enabled Findett Corp., a custom chemical manufacturing company in St. Charles, Missouri, to establish a joint venture with a newly formed Russian company called Polycom, Ltd. Together, the companies hope to introduce a chemical "microreactor," designed and built in Russia, to the polymer and chemical industry in this country. "You can carry it in your hands, but it can make millions of pounds of polymers and chemicals a day," claims Findett's chairman, Manuel E. Joaquim.

Behind the microreactor's deceptively plain exterior—it looks like a modestly elaborate pipe—is a decade-long Russian research and development effort combining theoretical insights from chemical kinetics, fluid dynamics, and thermodynamics with practical considerations of reactor design. Joaquim became convinced of the device's potential last year when Findett founder Milton Tegethoff visited an industrial center in Sterlitamak, about 1000 miles east of Moscow. Microreactors were already at work there generating chemicals and commodity polymers such as styrene-butadiene rubber and polyvinylchloride (the PVC of pipes, raincoats, and shoe soles), but Russian engineers treated their visitor to a demonstration. They unhooked input and output pipes from a conventional reaction vessel, holding roughly 30,000 gallons, and reattached them to a microreactor about one one-hundredth as heavy and one twentieth as bulky. The microreactor readily matched the conventional reaction vessel's output, Joaquim says.

What's more, he claims, such reactors turn out to be cheaper to run, produce fewer byproducts and yield a product with "essentially no contaminants." Though for proprietary reasons Joaquim would not reveal just how a reactor works, he would say that ingredients flowing into it undergo rapid and turbulent reactions. "You just pump the components together at the right place and time in the reactor along with a catalyst," he says.

The mighty mite of a reactor does have some drawbacks, Joaquim concedes. It can only handle reactions that can take place within a minute or two—though they include many commercially important processes. More troubling, he admits, is the inability to test microreactors on pilot-plant scales; to show their virtues, they have to be run at high volume. Furthermore, each one has to be tailored for a specific chemical process, so that it will create the right reaction conditions.

If the microreactor technology catches on, Kiser will profit from having brokered the deal; it reserved a minority interest in the joint venture. But the microreactor is not the only technological ore that Kiser has found in the grossly undertapped technowilderness to the East, says executive vice president Barney O'Meara. Another technology that he and others at Kiser think could lead to multiple joint ventures is a materials processing technique known as self-propagating high-temperature synthesis, or SHS for short. SHS, says O'Meara, could open the way to hundreds of new and often improved ceramics, metallic alloys, and ceramic-metal alloys known as cermets.

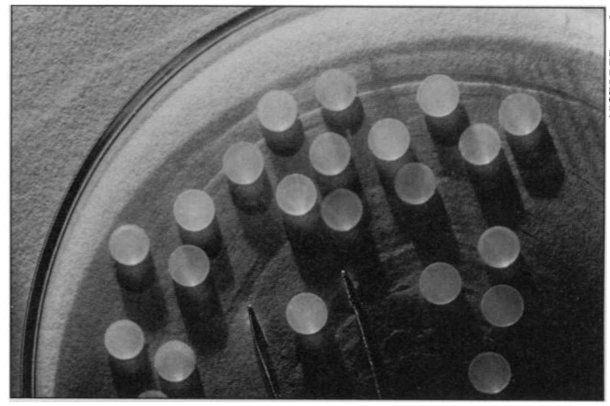
SHS converts a starting powder into a finished product by relying on exothermic reactions—chemical reactions that release more heat than is needed to initiate them—involving the ingredients of the ceramic or alloy itself. In a typical industrial SHS reaction, engineers mix ceramic and/or metallic powders, pack the mixture into a mold in the shape of the final product—an armor plate, a heating element, an engine part—and then ignite the SHS reaction with an electric spark or heat. A brilliant "solid flame" rapidly spreads through the entire reaction mixture, rather like a flame front traveling along a sparkler. The high temperatures along the flame front sinter the material into a solid product, which might be used as is or crushed to powder again for further processing. In effect, the material acts as its own furnace, and SHS advocates say the method also reduces processing times and automatically ousts volatile impurities.

Researchers in the West have been investigating the SHS process for years now (see article on page 1093), but the technology was first developed and scaled to production levels by scientists at the Institute of Structural Macrokinetics in Chernogolovka, about 50 miles from Moscow. And the Soviet commitment was on a scale unmatched in the West: Kiser claims the former Soviet Union had more than 2000 engineers at some 15 research facilities working on SHS technology. Seeing the opportunity, Kiser hatched a subsidiary called SHS Technology in 1990 to serve as commercial liaison for getting SHS materials, products, and technologies to Western industry.

Among the first takers is HiT$_C$ Superconco Inc. in Tullytown, Pennsylvania. The company has already imported more than 1000 pounds of high-temperature superconducting powder made in the former Soviet Union using SHS technology, according to its president Richard B. Cass. The powders are difficult to make by other techniques, says Cass—though he isn't always ecstatic about the quality of the shipments he gets from his Russian partner. "Sometimes it's as good as any material we have ever seen," he says, but his company has also received substandard shipments, including ones laced with particles of nonuniform sizes that can degrade products made from them.

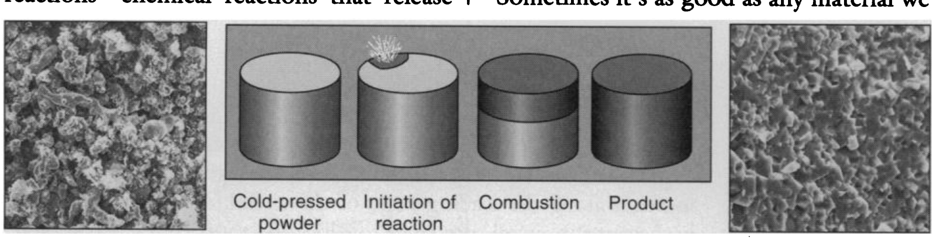
Technological entrepreneurs may have been quick off the mark in making new connections in the former Soviet Union, but academic researchers have been keeping pace. Take ceramic engineer James W. McCauley, a longtime SHS researcher and now the dean of the New York State College of Ceramics at Alfred University in Alfred, New York. A gratifying moment for McCauley came on 12 February, when his university signed a joint research agreement with Mikhail Shultz, director of the Institute of Silicate Chemistry in St. Petersburg, the premier glass research center in the former Soviet Union. The pact, brokered by McCauley and David Pi, director of the University's Center for Glass Research, provides for academic exchanges and opens the way for the university to provide modest financial and equipment support to its St. Petersburg partner. In return, McCauley says, the U.S. academics will gain firsthand experience of Soviet work on optical fibers, photonic components, and high-temperature ceramic superconductors. That agreement, notes McCauley, is just one of four that Alfred University has signed with premier materials research facilities in the former Soviet republics.

Like the domestic situation in those faraway places, such efforts are beset by uncertainties. But if McCauley and other Eastward-looking materials scientists and entrepreneurs return home with productive materials technologies and new ideas for basic research, their more cautious cohorts may follow them to the new technofrontier of the former Soviet Union. If so, just a few early successes could mean a steady stream of future vodka toasts. ■ **Ivan Amato**



VICTOREEN INC.

Crystal power. *Synthetic sapphires are being imported for use as radiation dosimeters.*



Hot innovation. *Self-propagating high-temperature synthesis transforms microscopic particles of titanium and boron* (left) *into a solid ceramic material.*

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