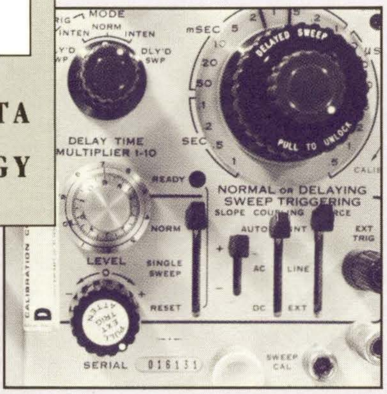
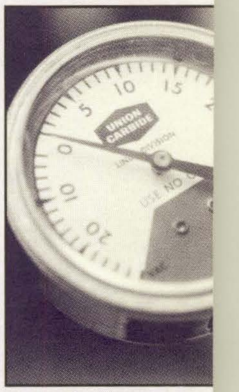
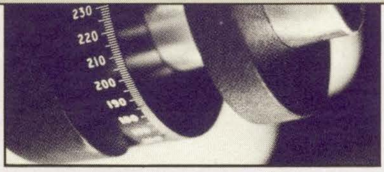
Spring 1988

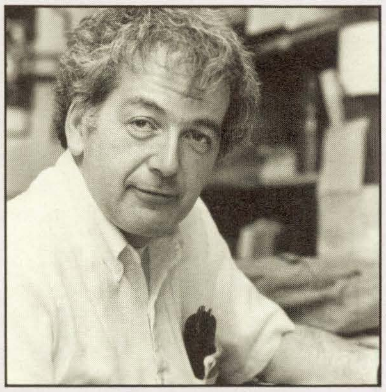
ITEMS

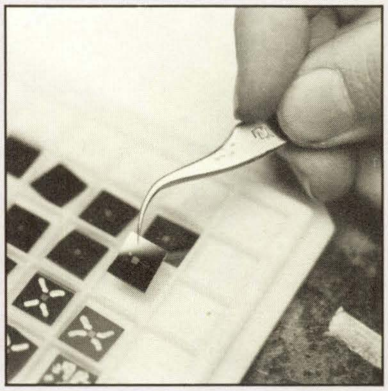
UNIVERSITY OF MINNESOTA
INSTITUTE OF TECHNOLOGY

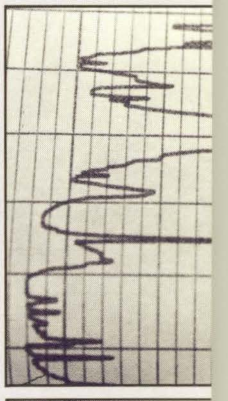


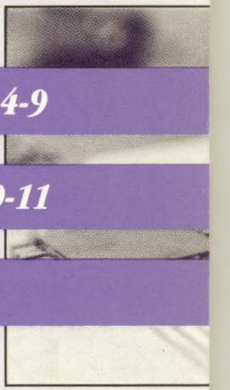












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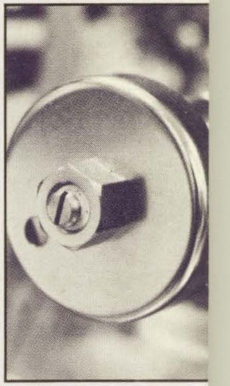

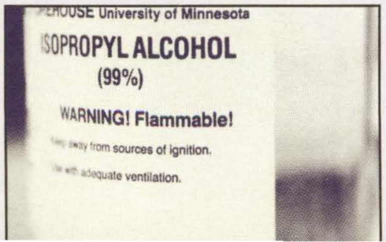

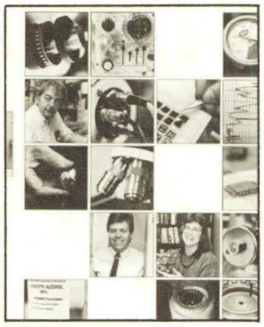

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Departments

ITEMS

University of Minnesota
Institute of Technology

Spring 1988

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Cover photos by Patrick O'Leary

Items is published three times a year to inform Institute of Technology alumni and friends about news, interesting alumni and faculty, and relevant issues. Letters to the editor, requests to receive *Items*, and notices of address changes should be sent to the Office of External Relations, Institute of Technology, 107 Walter Library, 117 Pleasant St. S.E., University of Minnesota, Minneapolis, MN 55455. *Items* welcomes letters and ideas from all readers.

This issue was prepared with the assistance of University Relations.

The University of Minnesota is an equal opportunity educator and employer.

About the cover: Photographer Patrick O'Leary captured close-up views of the vast elements behind materials research—from simple, identifiable items to parts of complex equipment. See pages 4-9 for more information about some of these photos.

NEWS

When the last bell rings, it's hats off to the class of 1988

Is there life after graduation? For Angela LaSell, a 21-year-old mechanical engineering senior with an alarmingly high grade-point average, the answer is a resounding yes.

LaSell is one of approximately 700 students who will attend IT's graduation ceremony Friday, June 3, at 7 p.m. in Northrop Auditorium. Highlights of this year's ceremony include a commencement address by professor Walter Massey, Argonne National Laboratory's vice president for research, and presentation of the 1988 George Taylor/IT Alumni Society Awards for teaching, research, and service.

LaSell has a strong incentive to attend the event. "My mom told me I better be in it, so I guess I'll go," she says with a laugh. Some 1,100 IT students will earn baccalaureate degrees this year, and many of them, like LaSell, combine work, study, and participation in University activities.

A full-time student, LaSell works 20 hours per week as an engineer at ADC Telecommunications. As part of the mechanical engineering department's cooperative education program, which matches talented students with work experiences, LaSell spent two quarters per year as a full-time ADC employee.

Despite her crowded work schedule, LaSell will graduate after only four years of college. She fulfilled several graduation requirements through extension night classes while working full time, and she's averaged 18 to 20 credits per quarter as a full-time student. "Four years went really fast," she says.

LaSell's activities extend beyond work; she's a contributor to IT publications, an IT senator for the Minnesota Student Association, and a member of the IT Student Board and the Student Senate. This year, she helped with a robotics research project, headed by assistant professor Homayoon Kazerooni and sponsored by the Undergraduate Research Opportunities Program.

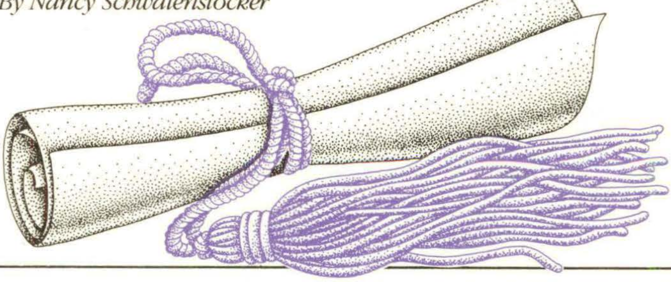
All this should be enough to land LaSell any job of her choosing. In fact, she went through interviews "just for the fun of it." When IBM offered her an engineering position, she turned down the job. Instead, LaSell will begin Northwestern University's MBA/JD program in August. She plans to become a corporate attorney, using her mechanical engineering background to understand the products of client companies.

With a future this well planned, LaSell feels prepared to leave IT. "I got what I was going to get out of it—I'm ready to move on," she says.

Like most graduates attending the ceremony, LaSell will wear a cap and gown, and her parents will be there to watch her receive her diploma and begin "life after graduation."

Family, friends, and other diploma watchers can get more information about commencement by calling Gail Fraser or Sandy Hummel at 612/624-8504. I

By Nancy Schwalenstocker



Supercomputers chart mathematical seas

The University's Cray-2 supercomputers will be the focal point of a three-year, $1.5 million National Science Foundation study of geometry.

Thirteen mathematicians in the U.S. and Europe will work together and with the supercomputers through NSFNET, the National Science Foundation's new national network. Mathematics professor Al Marden organized the group, which will develop algorithms for computer computation and display of mathematical objects. According to Marden, the project involves "the exploration of uncharted mathematical seas, computing and examining mathematical structures that have never been seen before." I

An apple for the teacher

A four-member student team from the University took third place in Apple Computer's "Design the PC of the Year 2000" contest with its entry "CORE," a portable PC that learns from its user's habits. Kevin Dooley, assistant professor of mechanical engineering, coached the team in the nationwide, 12-university competition. Team members were industrial engineering graduate students Lynn Linse and Michelle Vig and undergraduates Bill Burn (General College) and Scott Litman (history). The team flew to California for tours and presentation of awards—an Apple desktop publishing system for Dooley and $500 toward any Apple product for each team member. I

Student chapter wins award

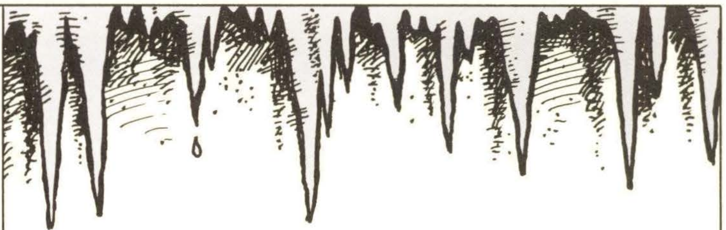
The American Water Resources Association named the University's student chapter 1987 outstanding chapter for its innovative programs and membership growth. Most student chapter members are graduate students from the civil and mineral engineering department's St. Anthony Falls Hydraulic Laboratory; a few are in agricultural engineering. Rollin Hotchkiss is student chapter president. I

Ellerbe chosen to design addition

After a national open competition, the State Designer Selection Board selected the international architectural firm of Ellerbe Associates to design the addition to the Architecture Building. Steven Holl of Ellerbe's New York office will lead the design team. The building addition will increase available space by more than 50 percent, allowing the School of Architecture and Landscape Architecture to consolidate in a single facility and expand its research activities. The 1987 state Legislature funded the planning phase for the $14 million addition. I

Noted

Rodney Brooks of the MIT Artificial Intelligence Laboratory delivered the Cray Lecture on May 23. ■ The Center for Interfacial Engineering co-sponsored an American Chemical Society symposium at the University in April. ■ The computer science department, the Minnesota Supercomputer Institute, and Control Data Corp. sponsored a workshop on supercomputers and large-scale optimization in May. Proceedings will be published. ■ The Mineral Resources Research Center (MRRC) and the Center for Professional Development, UMD, sponsored the 49th Annual Mining Symposium in January. I



MN-BRC: Soothing some of winter's sting

Minnesota's freezing winters and sweltering summers pose a difficult challenge to architects and builders.

Difficult, but not impossible. And definitely not impossible for the hardy Minnesota Cold Climate Building Research Center (MN-BRC) team.

MN-BRC operates on a simple principle: pool the talents of faculty in IT and other parts of the University to develop some regionally specific rules that can help guide the construction and operation of buildings in cold climates.

Only one year old, MN-BRC already has launched programs to look at a number of issues, including foundation insulation; technology transfer for architects and design professionals; energy and indoor environment; a low-income weatherization program; and daylighting/lighting of buildings. It also has established a public information center.

MN-BRC contributors include faculty from IT, the Department of Forest Products, the Department of Design, Housing, and Apparel, and the Department of Agricultural Engineering. Its acting co-directors are Lance LaVine, associate professor of architecture, and Ray Sterling, associate professor and director of the Underground Space Center.

MN-BRC researchers make it a point to consider the whole building, says LaVine. "We can't look at only parts of buildings," says Mary Vogel-Heffernan, research coordinator for the School of Architecture. "A building is greater than the sum of its parts. We need each other to inform each other about how buildings work, how to make buildings better."

To that end, when LaVine, who is an architect, designs a building that won't leak hot air in the winter, he must also know how to keep that building from trapping moisture and air pollutants. For help in that matter, he can turn to mechanical engineering faculty T.H. Kuehn and J.W. Ramsey, who conduct research on moisture in buildings. MN-BRC brings these key players together to solve such building problems.

While Kuehn and Ramsey study ways to keep the indoor environment clean, Susan Ubbelohde, assistant architecture professor, works on ways to use natural lighting in new buildings.

Since the invention of air conditioning and flourescent lighting in the 1930s, "people forgot about windows," she says. "And then they decided windows and skylights are ways energy leaks out of buildings." Ubbelohde advocates the use of natural daylight to conserve energy. As for windows leaking heat, "window technology will take care of that problem."

The funds to support this cold climate building research comes from a court settlement that required Exxon to pay back money it had overcharged its customers. (Similar settlements with other oil companies are pending.) The federal government reallocated Exxon money to states and gave Minnesota $36 million. In turn, Gov. Rudy Perpich gave MN-BRC $4.9 million.

In some form, the people of Minnesota will benefit from the endowment to MN-BRC, LaVine says. "Most of our projects are defined by the Exxon court ruling," he says. "They have to be applied and show benefit to the population."

"We're trying to make a difference in the way buildings are used," Vogel-Heffernan says. I

By Miriam Feldman

Living in a Material World

Seeking the "right stuff," IT researchers expand the frontiers of materials science

By Deane Morrison

From time immemorial people have reworked the raw materials of our planet, hoping to put together the "right stuff" and change society. The effort has led to everything from bronze and steel to teflon and chewing gum. Today, new materials promise different payoffs: cheaper electricity, lighter planes, faster computers, better dental crowns, and products yet unimagined.

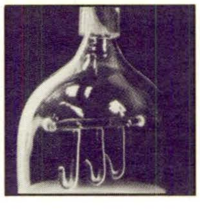
The quest to unlock the potential of materials involves a crew of IT researchers—materials scientists, physicists, chemical engineers, chemists, and aerospace engineers, to name a few. Some scrutinize bulk materials to see how they work and to improve them; others investigate the interactions of unlike molecules when different materials come together; still others work on the business side, trying to apply insights gained in the laboratory to the operations of technology companies. A look at the network shows the inner workings of what may lead to a materials revolution.

Photos by Patrick O'Leary

The stuff of planes

In the world of aerospace, light makes right. Provided, of course, that the materials are also strong and resilient. Composites of fibers embedded in a hard, light matrix usually fill the bill, and Robert Plunkett, aerospace engineering and mechanics professor, knows how to find the best ones.

"The use of composites began in the interior of planes," he says. "Next, they were used on the exteriors for sheathing, then for ailerons [wing sections or airfoils that tip the plane], rudders, and tail fins. Now they're beginning to be used for structural things. Up to 50 percent of a plane's structure is composites. They see extensive use on the Shuttle and other aerospace vehicles."



Furnace tube cap—organics burn off gels suspended from hooks

Composites connect control surfaces such as ailerons, rudders, and fins to the parts that move them. Plunkett develops ways to test various composites and to analyze systems using them, comparing the analysis to actual measurements. The composites usually consist of glass fibers, Kevlar—a tough organic fiber built by Du Pont—or plain old carbon fibers embedded in an organic matrix such as epoxy or a polyamide. None is flammable.

Carbon fibers, the strongest and stiffest of those Plunkett has tested, look like ordinary black threads. Under the microscope they appear woven. Chemically, they are just zigzagged chains of carbon atoms that began life as cotton fibers but have since been stripped of all elements except carbon.

"Most things expand when heated," Plunkett says. "But carbon fibers shorten—the angles between atoms change and the chain accordions. But the matrix gets bigger. The two trends fight each other, and it's possible to manipulate these properties so that the two trends cancel and you get no thermal change in size."

This convenient behavior has helped the design of space telescopes, whose movements in and out of shadows while in orbit could subject them to repeated heating and cooling. The distance between the mirror and the detector must remain constant in spite of this stress. In some cases, the matrix will crack, but this can actually help.

"We had a project to investigate the circumstances under which the matrix cracked and how to predict it," he says. "We wanted to see if the cracks would increase the damping, which helps stability. They do. As cracks open and close, surfaces work together to turn mechanical energy into heat energy." The mechanical energy that could have damaged the telescope shaft thus changes to a form that harmlessly dissipates into space.


Matthew Tirrell

Plunkett uses a supercomputer to study how laminated, fiber-reinforced materials break down under tension when a hole, say for a bolt or a rivet, has been drilled in them. Of course, no airplane manufacturer wants a wing or fuselage to come apart when subjected to the stress of flying, so all fibers must be as strong as possible. That means that they must be thin, generally half a micron or less.

"The fatter the fiber, the greater the possibility of a defect that can weaken the whole fiber," he explains.

Creating sticky scenarios

Down the street from Plunkett's office, Matthew Tirrell studies a different kind of strength: adhesion. A chemical engineering and materials science professor, Tirrell tackles questions of the molecular basis of adhesion, using organic polymers such as polystyrene and polyimide. These rather simple molecules, which when folded up on themselves extend only about 100 angstroms (the length of 40 water molecules), have attracted the attention of the microelectronics industry.

"The industry is interested in them as insulators and packaging for circuit boards," Tirrell says. As insulators, polymers must play a double role by sticking to current-conducting wires and withstanding the heat generated by the current. Some polymers must stick to other materials such as semiconductors or superconductors, which might be made from silicon or ceramic, respectively.

In getting down to the nitty-gritty of adhesion, Tirrell tries to separate the chemical components from the mechanical.

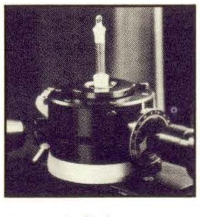
"All adhesion knowledge is based on gross mechanical tests," he says. "We devised a new test where we think we can measure the chemical component of adhesion directly. Our device lets us bring two very smooth surfaces together. We'll coat one surface with a single layer of polymer molecules, then apply it to another surface that's smooth and uncoated—mica, for example—or one that's coated with another material."

To test the strength of adhesion between the two surfaces, the device pulls them apart and measures the resisting force. "Because there are no bulk materials to be deformed, the only forces are from chemical bonds breaking or forming," Tirrell explains.

He inflicts this treatment most often on a class of polymers called block co-polymers. These behave as two polymers spliced together, with one part sticky and the other not. Any molecules that try to bind to the first layer will come in contact with the non-sticky part and be unable to hold on. Tape makes use of block co-polymers on the backing material that keeps it from sticking to itself while rolled up.

Polymers such as polystyrene and polyethylene have found plenty of uses in packaging, tubing, and other common objects. When the shape of the polymer product is important, the product must be formed by melting the polymers and forcing them into a mold. But molding stresses the polymers and could damage them if done too fast, Tirrell says.

"During molding, the polymers get sheared. They can freeze after being shear-stressed and the stress gets frozen in, producing a weak spot. If they are injected or molded slowly enough, they can take it. We're trying to understand the relationship between the speed of pouring or injection—during which they get deformed—and the size of the polymers. We've found that the time it takes a polymer to relax after being deformed is proportional to the cube of its molecular weight. So if you double the size of a polymer, you need to give it eight times as much time to relax before it gets frozen into its final position in the mold."

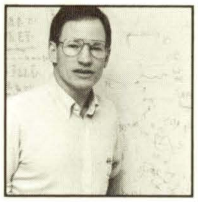

Dynamic light scatterer measures polymer-chain motion

Work by Timothy Lodge, an assistant chemistry professor, has revealed another caveat about pouring polymers too fast, Tirrell says. If a polymer's molecular structure is not a simple, straight chain but just a slightly branched one, the relaxation slows dramatically. This knowledge is applied in industry to mold polymers fast enough to keep them from cooling and gumming up the works, but not so fast that stress creates weak spots. The resulting polymer products make not only better insulators for microelectronics but better items such as car bumpers and non-squeak blackboards.

The simplicity of synthetic polymers makes them much easier to understand and work with than biological polymers such as DNA or proteins, Tirrell says. "Every biological polymer is a new story. But with the non-biological ones we can study one polymer and generalize about a whole class of polymers, then test the generalizations. We need to know only two characteristics: the length of the polymer chain and the chemical nature of the repeating unit. It's much simpler and less frustrating."

Speedy surface molecules

Another chemical engineering and materials science professor, John Weaver, studies different aspects of polymers and other materials. Weaver zeroes in on the chemical interactions between molecules at interfaces. Interfaces between different materials such as metals, semi-conductors, and polymers are crucial for information transfer in computer chips.


John Weaver

And, as Weaver points out, when chips shrink in size, surfaces and interfaces between surfaces become more critical to the proper functioning of chips.

Unfortunately, even the smoothest chunk of a solid material looks rugged as a mountain range on the atomic scale. But almost all theories to date assume surfaces smooth down to the last atom, Weaver says. The challenge: to understand non-bulk solids, whose extreme thinness means that the properties of their surface regions, which may be highly disordered, contribute significantly to the overall properties of the solid.

In making microelectronics devices such as transistors, beams of atoms are often deposited on surfaces of other materials to make a composite structure with the desired properties. For example, aluminum may be deposited on the semiconductor material gallium arsenide, which plays a role similar to silicon in computer chips. The interplay between gallium, arsenic, and aluminum atoms during the deposition shapes the interface and thus the properties of the device. This interplay figures prominently in Weaver's research.

After directing light or electron beams through samples of gallium arsenide at successive stages of the deposition process, Weaver examines the frequencies of emitted photons or electrons for clues to how the environment has changed from an atom's point of view. For example, he can tell that an aluminum atom has penetrated the gallium arsenide lattice and replaced a gallium atom, which now sits atop the lattice.

As more aluminum atoms are deposited onto the gallium arsenide substrate, more replacements occur and the lattice surface takes on a different character. Clumps of gallium and aluminum may build up on top of the lattice, creating areas where a new surface abuts the original lattice surface. Or, the surface of the clumps may sit on a mixed layer of arsenic, gallium, and aluminum. Similar interactions can occur between combinations of other materials, including polymers and superconductors.


Isolation valve on Weaver's inverse photoelectron spectrometer

Because the surfaces, as "seen" by atoms, are rough and atomic interchanges can happen pretty fast, it's hard to predict surface behavior, Weaver says.

Predictable or not, the outcomes of these ultra-fast activities shape the areas of contact between surfaces. These in turn hold the key to a device's electronic properties and govern the amount of adhesion between the materials. In other words, whether a device stays intact and works right depends largely on interfaces between its component materials. Painting a complete picture of interfaces requires several angles of attack, so Tirrell works closely with Weaver to compare findings.

"We try to relate what we see mechanically to what he sees chemically," Tirrell says. "For example, if we put a carboxylic acid group [a carbon, a hydrogen, and two oxygen atoms] on a polymer, attach it to a surface, and notice that adhesion with another polymer is increased, we look to see if we can relate that to a chemical bond John can see forming."

The art of ceramics

Only sophisticated equipment can detect the effects of chemical bond formation in the materials Weaver and Tirrell investigate, but the effects are quite obvious in Martha Mecartney's materials. Anyone who fires ceramic pots knows how the soft, pliant walls turn stiff and brittle in the heat. Mecartney, an assistant chemical engineering and materials science professor, looks at the microstructure of ceramics materials.

Ceramics may be easier to recognize than to define. Mecartney calls them "everything that's not a polymer or a metal," although they may contain either as parts of a heterogeneous whole. A versatile lot, they include zirconia, a tough material that may be useful in protecting dental crowns and engine pistons from wearing out, and the newest superconductors.

The typical ceramic is made from a powder, which is then heated—fired, in ceramics lingo—and its components fused. But the sol-gel process, a procedure similar to jello-making, opens up new possibilities. Ceramic rope, for example.

"We can make fibers from chemicals—not powders—that contain the right elements. For glass fibers, we use organic compounds that include silicon," Mecartney says. "We put them in solution and add catalysts to make the silicon and oxygen atoms link up and polymerize. That forms the gel network. It looks like jello and has the same properties. You can choose a point before it completely sets and draw out a fiber, then pass it through a furnace to burn off the organics. What's left is whatever metal and oxygen you started with. Or, you can spread out the mixture to make a thin film."

Holding up a thick piece of rope, she warns against touching it and picking up a ceramic splinter. The rope is mullite, an aluminum-silicon-oxygen rope. Mecartney makes similar sol-gel ceramics and samples them as they build to their final structure. She then examines them for the microscopic events that produce the big changes in their texture and behavior.


Martha Mecartney

"I'm interested in understanding what changes the viscosity of materials," she says. "I have students looking at how the network structure builds up. Using the transmission electron microscope—the 'TEM'—you can see clusters grow. I try to relate the change in viscosity to the TEM pictures and build models of what happens chemically to form the networks.

"One student is looking at lead-zirconium-titanate. We're trying to make thin films with the sol-gel process for ferroelectric memory cells, which could be used as a switching device by applying an electric field. Honeywell is interested in whether this will work on top of silicon substrates."

In some cases, impurities control the ceramic properties, Mecartney says. In studying many commercial ceramics, she finds that such impurities as aluminum, boron, calcium, and magnesium silicates tend to gather at boundaries between the microscopic grains, or crystals, of the material. Whether that's good or not depends on the ceramic and the particular impurity.

"We want to know how they help or prevent toughening of the ceramic," Mecartney says. "We can add different impurities and measure the changes in toughness. For instance, if we add yttria to zirconia it toughens it. But if all the yttria leaches out into the grain boundary impurity phase, the zirconia cracks into little pieces."

The impurities also work their magic or mischief by changing the shape of the grains, she says. Sometimes a material toughens in response to firing, when the material inside the grains and the silicate impurities outside cool and contract at different speeds. If not extreme, this imbalance may create stresses that can be stored in the grain structure to toughen it.

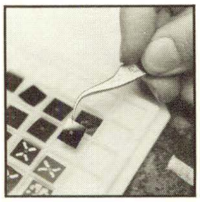
While toughness is desirable in many ceramics, other qualities may weigh more heavily. In another class of materials Mecartney studies—the new ceramic superconductors—electrical properties are most important. Like all other superconductors, these materials completely lose their electrical resistance when cooled below a certain transition temperature. But their transitions occur at temperatures unheard of two years ago: 90 and even 125 degrees Kelvin, far above the 23 K barrier that had held back superconductivity research for a decade.

The path of least resistance

Besides conducting current resistance-free, superconductors can expel magnetic fields applied to them. This ability may be used to make frictionless bearings or magnetic shields, and resistanceless current means much cheaper electricity. But even the best superconductors have their limits; when a critical amount of current or strength of magnetic field is reached, the material will fail and revert to a non-superconductive state.

Mecartney has joined forces with physics professor Allen Goldman, who ranks among the world's top 10 superconductivity researchers, to figure out what makes the new ceramic superconductors tick. While Mecartney works mainly on determining the microstructure of the materials, Goldman studies their electrical properties. Together they hope to discover how a material's structure affects its electrical behavior.

They focus their efforts on a ceramic made from yttrium, barium, and copper, in the ratio 1-2-3, plus oxygen. Under the electron microscope, the compound is a lattice of atoms, but its precise structure depends on how it was processed. For example, firing the material at just 25 degrees higher than the usual 925 degrees Celsius can hurt the material's ability to "go superconductive" at 90 K and to carry


Samples of thin films

current without failing. Mecartney explains why:

"The trouble is, the temperature doesn't affect all components equally," she says. "Intuitively, one might think higher firing temperatures would always be good because there would be better bonding between particles and better mixing. But the copper and maybe other components melt and coat the grains, and the melted material isn't in the 1-2-3 ratio. This decreases the critical temperature and the amount of current it can superconduct."


Allen Goldman

Other defects such as a "twinned" crystal structure also can play havoc with superconductivity. At about 600 C the yttrium-barium-copper lattice distorts symmetrically on either side of a plane running through the middle, resulting in a twinned crystal visible through the electron microscope. These twins could disturb the path of superconducting electrons, Mecartney says.

For Goldman's part, the challenge lies both in learning to prepare consistently high-quality materials and in choosing the theory that best explains the phenomenon of superconductivity. He experiments with very thin (about 0.9 microns) films of yttrium-barium-copper oxide, "trying to come up with some experiments clearly enough defined to let one distinguish between the large number of competing models for superconductivity," he says.

His thin films can be quite practical, too. "Some structures we need to produce for basic research are very practical," Goldman says. "For example, if you want to make a device to investigate superconductivity, the device can be used for infrared wave detection, high-speed switches, magnetometers, and low-noise amplifiers."

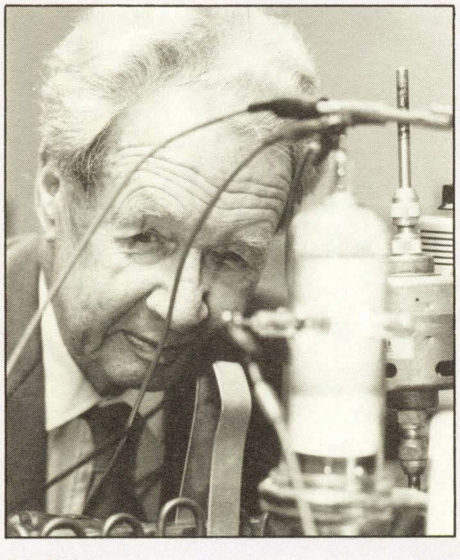
Still, the world of superconductivity resembles an Alice's Wonderland of bizarre electronic behavior. Although his films are superconductive, Goldman observes in them lots of strange electrical, electronic, and magnetic events that may have nothing to do with superconductivity. This doesn't ease the task of choosing the best explanation for the phenomenon.

"Whatever causes superconductivity, it must involve a pairing of electrons," he says. "But there are lots of different brands of 'glue,' for example vibrations and interactions of the lattice atoms. Other types of glue depend on the magnetic properties of the material or the number of electrons in the copper and oxygen atoms. It's a can of worms. It's like the hall of mirrors—things are not what they seem to be. The field is literally out of control."

Simplifying the making of a great thin film

The new ceramic superconductors may be the hottest topic in physics, but making them is no fun. Sure, the latest ones "go superconductive" below a relatively scorching 125 degrees Kelvin, but only if their composition is precisely right. Since they are usually fashioned as films a few thousand angstroms thick, getting the exact ratio of elements in that film presents a real challenge.

Rising to the challenge, G.K. Wehner, electrical engineering professor emeritus, came up with an elegant idea to simplify the making of thin films. He told physics professor Allen Goldman about it, and soon graduate students Young Ho Kim and Dong Ho Kim, of electrical engineering and physics respectively, were also involved in putting Wehner's idea to work. How did it work? Like a charm.


G.K. Wehner

Wehner's idea, for which he has applied for a patent, changes the geometry of thin film manufacturing. The most common method is sputtering, in which a flat target containing the elements of the superconductor material in the right proportions is bombarded with ions to dislodge its atoms. The dislodged atoms are then collected on a surface, where they build up to form a thin film.

For example, if a film is to consist of three main elements, then conventional sputtering might use a single target of the compound itself or three separate targets, each containing one element. Using a single target would be simplest, but because the atoms of the different elements scatter at different angles, it is very hard or impossible to position a collecting surface for a film to receive the same proportions of atoms as the target material.

Wehner solved the problem by replacing flat targets with spherical ones. That way, although the atoms of different elements are still dislodged at different angles, the curvature of the target ensures that atoms coming off at all angles will combine to form films with the same composition as the target.

Using the new method, the scientists produced some of the new high-temperature superconducting films containing yttrium, barium, and copper in the desired ratio of 1-2-3. They behaved just as expected; they had nearly an ideal crystal structure and became fully superconductive below 89 K. Their quality rivaled that of films made by far more complicated methods.

Machines for making thin films can cost $600,000 or more, but one using the new process should be considerably cheaper, Wehner and Goldman say. The process will also be easier to control, easier to scale up, and suited for making films with very complex compositions. That should come in handy in making the latest generation of superconductors, which achieve superconductivity below about 125 K and comprise four metallic elements.

By Deane Morrison

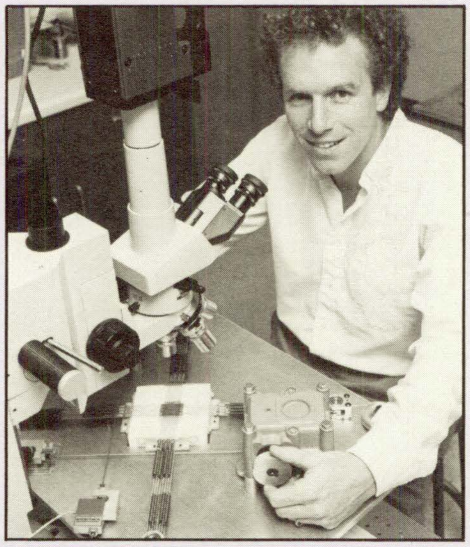
This engine prefers its coffee black

A machine that runs on coffee? A metal car bumper that straightens itself out after a fender bender? An antenna that can assemble itself on a spaceship?

These are just a few of the futuristic products that could spin off from research on shape-memory metals, which re-form themselves after being bent, folded, or twisted. Sometimes they re-form at room temperature, sometimes in response to heating, but their memories for their former shapes work amazingly well. Richard James, an aerospace engineering and mechanics associate professor, knows all about them. In addition to his formal research apparatus, he keeps on hand a couple of simple "engines" that use the shape memory of nitinol, a nickel-titanium alloy.

James' coffee-cup engine is simple: one brass and one plastic wheel connected across a boomerang-shaped frame by a nitinol wire. When dunked in hot coffee (actually any hot liquid would do), the brass wheel heats the wire as it passes over the wheel. Stressed by being bent where it passes over the wheel, the wire tries to return to its original straight shape, creating tension that moves the wheels. In a few seconds both are spinning fast. A similar engine uses a nitinol wire as an ice cutter.

When a nitinol wire re-forms itself it undergoes a phase transformation much like the transformation of water to steam—except the phases are both solid in the wire's case. Some memory metals, such as the wire in James' coffee engine, must be heated in order to re-form, which means the transformation can only occur at a higher temperature. With a small enough temperature difference and a strong enough force exerted by a re-forming piece of memory metal, the metal could be harnessed for a variety of uses.



Dick James

"I'm researching the feasibility of making a large-scale, efficient engine out of this material," James says. "It could run on much smaller temperature differences than current engines, say, the temperature difference between Lake Superior and the air above it or on waste heat. But we need to understand the basics of stress-induced phase transformations first."

It would save NASA a lot of trouble if an antenna could be made from memory metal and stored. When put in place and heated by the sun, it would resume its original shape. And who knows how much money in repairs could be saved if bumpers were made from memory metal? Even if they had to be heated to re-form themselves it would be a lot cheaper than replacing them. But these dreams, says James, all lie in the future. For now we'll just have to use coffee for drinking and keep up our car insurance. I

By Deane Morrison

Mysterious memory metals

Maybe that's what happens when metals like copper, barium, and yttrium start acting like ceramics. But stranger things than superconductivity happen with other metals when they're put together in an alloy; some act like rubber. These "shape-memory metals" seem to "remember" their original shapes when bent and return to them spontaneously, just as a rubber band would.

A wire remembers its former shape

Well, not always quite spontaneously; some memory metals must have their "memories" jogged by heating. Still, these remarkable alloys offer a wealth of insights on how new combinations of materials can behave. Richard James, an aerospace engineering and mechanics associate professor, studies memory metals, keeping an eye out for the big discovery in this wide-open area of materials research.

These alloys' peculiar behavior comes from stress-induced phase transformations, James says. They resemble the phase transformations between water, ice, and steam except that in memory metals all the transformations occur between solid phases. Also, different types of stress cause the phase transformations in water and memory metals. For example, the pressure of an ice skate causes a local melting of ice—transforming it to a liquid phase and leaving a small amount of liquid on which the skate slides. But unlike water, memory metals respond to the whole stress, especially shear stress, and not pressure, James says.

Memory metals' phase transformations, and thus their ability to spring back to their original shapes, depend on the temperature. For example, bend a paper clip made from nitinol, a nickel-titanium alloy with shape memory. If the phase transformation occurred below room temperature, then the clip would be "superelastic" and would spontaneously re-form into a clip shape. If it occurred above room temperature, the bent clip would re-form when heated.

Superelasticity comes in handy for the Minneapolis Flexmedics Co. in making dental arch wires used in braces, according to James. "To make braces now, we use stainless steel wire that must be tightened every month. But the new nitinol wire accommodates as teeth move and needs tightening much less often," he says. The company also uses memory metal to make a surgical self-retracting hook for grabbing and letting go of tissues, he adds.

Airplane designers splice hydraulic pipes with memory metals by making a memory-metal tube with a smaller diameter than the two pipes to be joined. They then expand the tube and insert the two pipes so that their ends touch in the middle. Heating the tube causes it to shrink toward its original diameter, making a tight seal. Also, the new superelastic nitinol eyeglass frames can resist permanent ruin when sat upon.

The key to understanding shape-memory metals lies in the behavior of the microscopic crystals that compose the alloys. James has built a biaxial loading device, resembling a medieval torture rack, to stress little plates of the materials by pulling on the edges. With it he measures the crystals' properties, for instance the temperature at which phase transformations occur and the crystal orientations.

In a typical experiment, he subjects the material to unequal stress in two directions. Starting above the temperature of transformation, he slowly cools the material.

"Different metals return to their original shape at different temperatures," he says. "If we do enough experiments, we get an idea how the composition affects the transition temperature. We also use our knowledge of how molecules behave in crystals to predict behavior. Most of it is at the basic stage of developing theoretical models." Modeling is important, he says, because there would never be enough time to test every possible alloy under all conditions by trial and error.


Port on Goldman's ultra-high vacuum chamber

Since February, James has been making his own memory metals in a crystal grower. The machine enables him to seed a single microscopic crystal, for example copper-aluminum-nickel, and grow it until it weighs about a pound. He then slices off samples to test.

"The big discovery in this field hasn't been made yet," James says. But he'll know it if he sees it: a material that doesn't need much heating to start re-forming itself and that delivers a terrific force when doing so. It would be a mechanic's dream.

Creating ties that bind

This glimpse at materials research covers only a few of the many University faculty involved. The whole effort extends over several departments, including many more faculty, their graduate students, and postdoctoral fellows. Yet this scientific work could fall short of its goal if the research doesn't find its way into the industries that could put it to work. That scenario bothers Fennell Evans, a chemical engineering and materials science professor who also heads the new cross-disciplinary Center for Interfacial Engineering (CIE).

In the United States, scientists from industry and academia don't interact nearly enough, Evans says. Meanwhile, some of our strongest competitors in high technology, namely the Germans and Japanese, have set up centers to address any high-tech problem with experts from both realms. To help remedy the situation, Evans has applied to the National Science Foundation for matching funds to support CIE for five years.

Solutions undergoing the sol-gel process

CIE would bring together researchers in areas involving interfaces between materials—John Weaver and Matt Tirrell, for example—with their counterparts in American companies, Evans says. The overall goal is better control of systems that depend on interfaces, such as computer chips and high-strength composite materials. The center also would support industrial scientists who visit for extended periods. As Evans explains it, the Japanese have had the right idea for a long time; now American companies must learn that it pays to send their scientists and engineers to universities where they can become directly involved in research.

"This year five professors and Ph.D.s from Japan came here for a year, and their visits are paid for by their company or the Japanese government," Evans says. "No people from U.S. companies did that. U.S. people come in for, usually, a two-day show-and-tell.

"I set up a visitation program whereby people come from industry for three months. The problem has been that people advancing fast in industry won't leave their jobs for long, and the companies don't want to let them go. But these visiting industrial fellows will be here long enough to get something started. If they get involved in advising graduate students, we'll appoint them as adjunct professors. We hope these relationships will last. Five or 10 will come this summer, and one company is running this opportunity as a contest."

Robert Gee, CIE's new director of technology transfer, will help smooth their way. Gee, who has been a vice president in several major technology companies, understands the "interface" between companies and universities well, and can speak the jargon of both worlds.

"I'm here to augment, supplement, and expedite," Gee says. "I've analyzed what went wrong and right with many cooperative research ventures. We'll be trying novel ideas. At the University of Minnesota, there's a lot more than what traditionally goes on between universities and companies," he says.

If CIE succeeds in forging strong links to companies nationwide, it will strengthen materials research at both the University and the participating companies. It can't happen too soon, because we do indeed live in a material world. As Richard James puts it, many technologies are limited by materials, not design. In other words, there's plenty of room for new "stuff" under the sun. **I**

Deane Morrison covers science and technology issues for the University News Service.

The Big Chill

Geologist John Splettstoesser ignores brittle winds and cold temps to pursue antarctic studies

By Deane Morrison

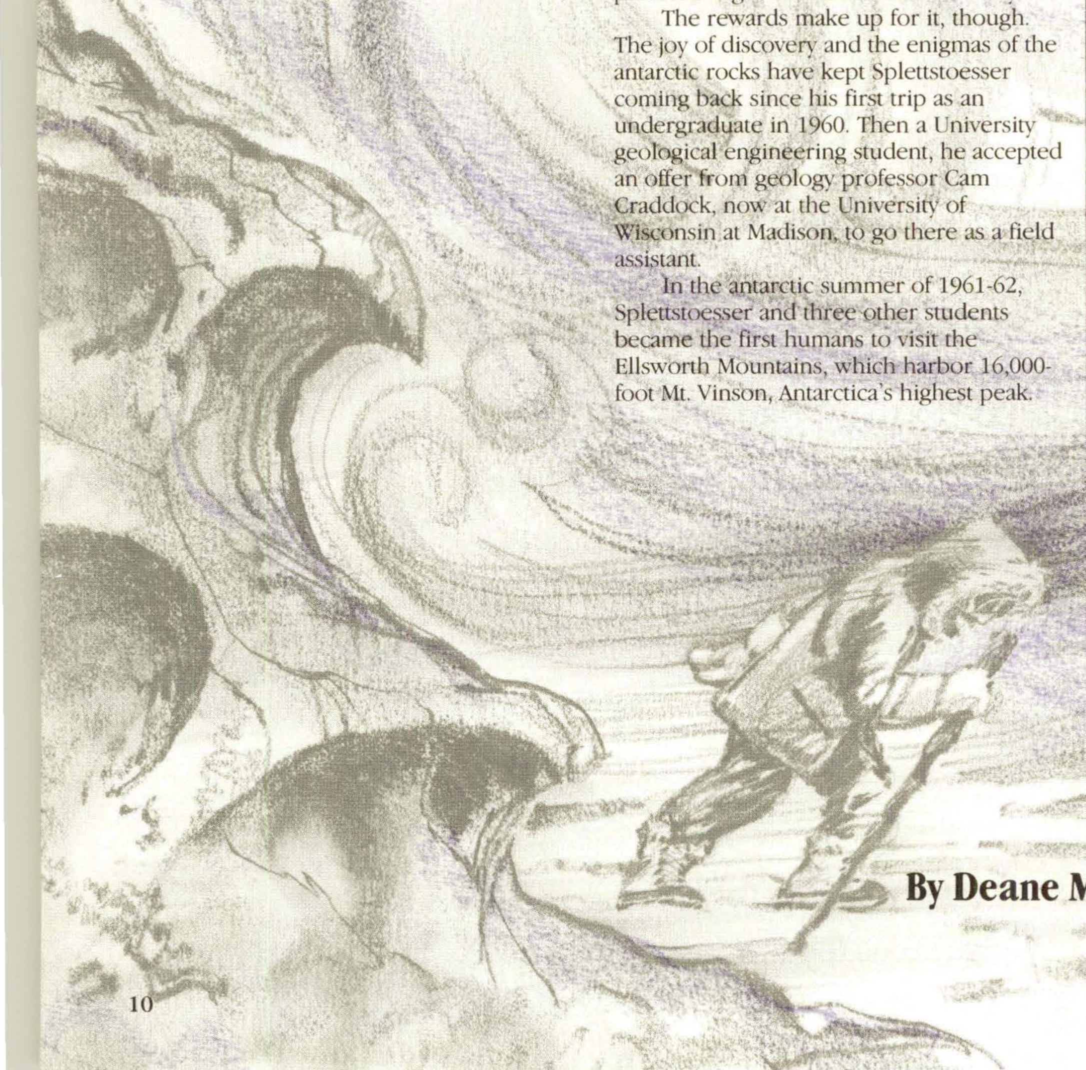


Illustration by Mike Patrick

In winter, it clogs the harbors with ice floes. Every day it chips away at exposed rocks, honing them as if by the hand of a bizarre modern sculptor. Sometimes it turns helicopters into helpless toys, hurling them toward the rocky mountains with a force that not even the best pilot can escape.

The wind is the one constant in Antarctica, where University geologist John Splettstoesser has built a career studying the strange land and rock forms unseen by human eyes until this century. He has felt its force from inside a helicopter that was nearly crushed against a mountain and has seen the wrecks of other choppers and planes. Danger comes with the territory.

The rewards make up for it, though. The joy of discovery and the enigmas of the antarctic rocks have kept Splettstoesser coming back since his first trip as an undergraduate in 1960. Then a University geological engineering student, he accepted an offer from geology professor Cam Craddock, now at the University of Wisconsin at Madison, to go there as a field assistant.

In the antarctic summer of 1961-62, Splettstoesser and three other students became the first humans to visit the Ellsworth Mountains, which harbor 16,000-foot Mt. Vinson, Antarctica's highest peak. With the continent largely unmapped, pioneers could literally name any features after themselves. So now the Ellsworths boast the Splettstoesser Glacier, among other points of interest.

The antarctic ice sheet is so thick that its melting would send ocean waves lapping at the Statue of Liberty's chin. It's no surprise, then, that Splettstoesser and other geologists devote much of their effort to studying ice advances and retreats. The weirdly sculpted rocks resulting from ice movements, known as ventifacts, offer some clues.

"Ventifacts are used in areas where there's no other means of dating the ice retreat," Splettstoesser says. "The longer they've been exposed by retreating ice, the more pitted their appearance. The wind even loops around and eventually undercuts the rocks—they get pitted on the lee side by vorticity and negative pressure."

Splettstoesser keeps a collection of ventifacts in his office at the Minnesota Geological Survey. The tops of some sport a pattern of holes resembling a vegetable

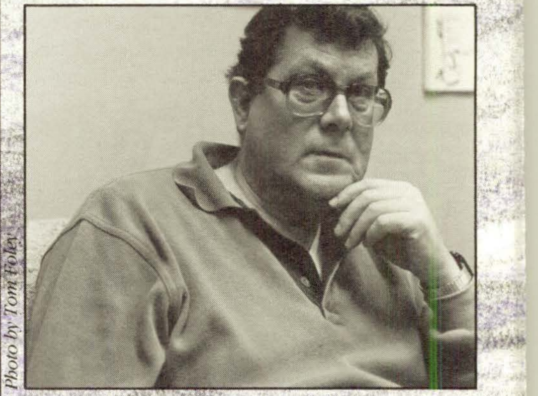


Photo by Tom Foley

John Splettstoesser

grater. One sits on three legs, the result of wind whipping around and cutting out much of its underside. It takes a long time to produce patterns like these; field estimates usually run in centuries, Splettstoesser says. But he and Marion Whitney, a geologist at Central Michigan University, have estimated time periods up to thousands of years based on wind-tunnel tests.

Ventifacts don't turn up everywhere. Splettstoesser studied them extensively in the interior beginning in 1978-79, but finds fewer in the antarctic peninsula, where a strip of the continent snakes up toward South America. He also has found them in Greenland and Israel.

"The ice age occurred rather recently in the peninsula," Splettstoesser explains. "You find freshly exposed areas without evidence of ventifacts." Comparing the degree of sculpting in ventifacts from areas recently and not so recently uncovered will help him determine when the ice withdrew from areas whose glacial record isn't known. That information can help draw a larger picture of changes in the overall thickness of the ice sheet and how fast they occur.

Another important factor in antarctic geology is the history of sea-level changes, affected by both the timetable and the extent of glaciation. Other factors such as the movements of Earth's crustal plates, which produce continental drift, also may play a role. Splettstoesser, then, must carefully interpret the evidence of sea-level changes to sort out the geologic history of a region. The Falkland Islands are a case in point.

"The Falklands were glaciated, but not with a large ice sheet like those in Greenland and Antarctica. So they aren't rebounding from the glacier," Splettstoesser says. "They may be changing elevation due to movements of crustal plates. South America and Africa are still separating."

The Falklands yielded a clue to a new way of tracing sea-level fluctuations: penguin scratches. Rockhopper penguins scratch rocks while hopping around near the seashore; thus scratches from ancient rockhopper colonies can be correlated with sea level at different times in geological history. But Splettstoesser unfortunately has a harder time reaching these rocks than the birds do.

"The scratches occur mostly in hard-to-reach areas, but I can't get away with visiting just one," he says. "I need to get a lot of correlations from different places because in the Falklands, for example, crustal movements may have raised or lowered the scratches. That has nothing to do with sea-level changes. More striation data from inaccessible islands that ring Antarctica would be welcome. The better the spread of places, the better the data. Cruise ships may stop at some, but you'd have a hard time getting a research vessel to go on an expedition to these places or to drop you off there."

The antarctic ice sheet is so thick that its melting would send ocean waves lapping at the Statue of Liberty's chin.

In other words, you can't always get where you want.

Splettstoesser first discovered the penguin scratches as a resident geologist on a cruise ship, a job he often takes during vacations. For the most part, cruises don't stop at islands long enough to do any substantial research, he says; they let passengers out to explore beaches for an hour or two, and that's it.

Cruises do offer him a chance to share his expertise with paying passengers and at least scout out potential future research sites. Splettstoesser has made voyages with Society Expeditions—a company whose slogan is "We go where nobody else does"—and with ships chartered by other organizations. Most set out from Punta Arenas, Chile, and head for the peninsula and perhaps some South Atlantic islands.

Society Expeditions offered a new travel package last fall: the first commercial flight to the South Pole, with Splettstoesser supplying geology lectures and personal anecdotes of his extensive travels. Fourteen passengers paid about $36,000 apiece for the jaunt. The usual cruise to the peninsula costs anywhere from $5,000 to $10,000, he says.

The trip included a series of short hops along the peninsula, visits to inland base camps such as one at Mt. Vinson, and then a stop at the pole. The plane landed at Amundsen-Scott Station, an American-run research outpost about 200 yards from the pole, for pictures and champagne.

The location of the pole can be measured to within a meter with the aid of a ground-based geodetic receiver in communication with satellites, Splettstoesser says. But the flag that marks the exact spot must be repositioned regularly because of ice movements in the area. The ice sheet moves about 10 meters per year, or an inch a day, toward Southern Africa.

Back in Minnesota, Splettstoesser finds himself with more demands on his expertise. Will Steger, the arctic explorer who co-led a dogsled expedition to the North Pole in 1986, has asked him to serve on the board of directors for Steger's 1989 dogsled trek across Antarctica. Splettstoesser, who will gladly advise him on the rigors of overland travel in the antarctic, says that Steger's trip, if successful, will be the last great antarctic exploration.

"He plans to cross from the tip of the peninsula to the pole and then across the continent to Mirnyi, a Russian station," Splettstoesser says. "He is interested mainly in surface conditions in the interior, particularly how to deal with crevasses, which are tension cracks in the ice, and also sastrugi—wind-sculpted surface ridges that are very hard and resist sled movements. They get up to two feet high and can make a sound like a bell if you knock one with a sled runner."

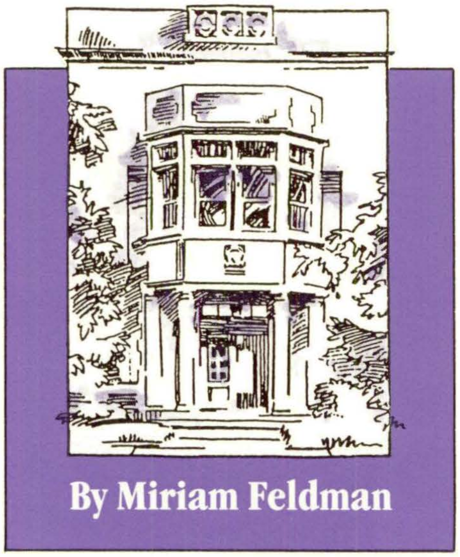
Splettstoesser also is working with Cam Craddock and professor Gerald Webers of Macalester College in St. Paul to put the finishing touches on a Geological Society of America memoir. The memoir, scheduled to be published in 1988, describes the geology of the Ellsworth Mountains.

Despite the drawbacks to working in the antarctic, Splettstoesser says the place never loses its charm. "I can't wait to get back." **I**

Deane Morrison covers science and technology for the University News Service.

Meetings of Minds

University conferences work to form a more perfect union of experts



By Miriam Feldman

Pity the water resources specialists, victims of Mother Nature. Their conference was cancelled; it slip-slided away when glare ice made roads impassable.

Excluding acts of nature, though, everything for the most part runs quite smoothly for John Vollum, director of the science, technology, and engineering branch of the University's Professional Development and Conference Services (PDCS) program. Vollum and five staff members plan 50 to 60 conferences a year on everything from artificial intelligence to water resources.

Of course, there are the occasional times when speakers fall off the stage or don't show, but the benefits to thousands that attend the conferences outweigh the relatively few problems. Consider just a few of the conferences planned by PDCS within the past year:

- **29th U.S. Symposium on Rock Mechanics.** The University will host this conference, expected to draw 450 scholars from 25 countries.
- **1988 Structural Engineering Seminar Series.** Practicing engineers and architects meet University engineering faculty in a spring seminar series that covers topics such as the design and construction of temporary retaining walls and the lateral structural stability of the Norwest Bank Building.
- **Tropical Forests: the Minnesota Connection.** Organized by the Bell Museum of Natural History, this conference brings together community members, professional ecologists, and policy makers to talk about the destruction of tropical rain forests and the impact that has on the world's environment.

PDSC "is a service to the faculty and the community," Vollum says. The exchange of information between University scholars and the professional community is a cornerstone of PDCS programs. Conference topics must fall within the realm of subjects taught at the University, Vollum says.

About a dozen PDCS-run conferences are annual affairs, including the long-running conference on soil mechanics and foundation engineering. Miles Kersten, civil and mineral engineering professor emeritus, and some colleagues at the highway department and the U.S. Army Corps of Engineers organized that conference 36 years ago. About 50 people attended the first conference, held in the chapel of Nolte Center, says Kersten. "Fees that first year were five dollars, maybe even two," recalls Kersten, who says he's "the only one that's still around from the original committee."

Today several hundred people pay more than $100 apiece to attend the day-long soils conference, which draws speakers from across the country. The conference just "grew and kept going," Kersten remarks.

Thirty-six years ago, however, "soils was somewhat a new subject," Kersten says. Practicing engineers wanted to know more about this new area. The conference was a way of bringing new information to practicing engineers, but at the same time, "we were learning things from them."

Supported by University funds and conference fees, PDCS is not a money-maker. "When you start to look at it as a money-maker, you run into problems. You start looking at topics not of interest to the University," Vollum says.

PDCS services also are available to groups outside the University. One of the most successful external collaborations began in 1978, when Honeywell Inc. asked PDCS to organize a continuing education program for top-level managers. The result has been an annual week-long program called **Modern Technical Concepts.** Vollum describes it as "a reimmersion of engineers in current engineering and science topics."

Just as he does for other conferences, Vollum arranges everything from the speakers (IT faculty teach the classes) to the hotel and meals. "Honeywell tells us areas they would like us to emphasize, and from there on we design it."

Jack Ruff, manager of Honeywell's Corporate Technical Education Center, says managers have to get back to the classroom because recent college graduates often are more competent than they are in certain areas, such as computers. The classes, says Vollum, bring the managers up to date and "restore their confidence in engineering decision making."

The Honeywell program frequently sparks a working relationship between the corporation and University engineers. "Very often," says Ruff, "people in one of the operating divisions of Honeywell will contract with a professor to do some research."

Vollum says the most memorable conference for him is **Light and Glass in Architecture.** The conference brought artists and artisans together with architects to gain some mutual understanding. In the period of modernism, architects lost contact with the arts and many of the embellishments created by artists and artisans disappeared from buildings, Vollum explains.

The conference attracted some of the world's best stained-glass artists. "The visible interaction and development that took place here," was exciting to observe, he says. The conference taught artists how to prepare presentations for architects and taught architects how to better employ the talents of artists, Vollum says. "I felt that conference made a difference."

For more information on conference planning services, call John Vollum at 612/625-1534. I

Miriam Feldman is a free-lance writer who lives in the Twin Cities.

ALUMNI

Off like a Schott: Electric interest sparks corporate growth

Oscar Schott grew up on a farm in Hinkley, Minn., in the days before rural electrification. In 1924 the family farm saw the light from its own battery-powered plant. Schott remembers when the cream separator was converted to electric power and when motors began pumping water.

The youngster who watched with excitement as electricity transformed his family life is now chairman of the board of Schott Corp., which manufactures and designs transformers, inductors, and magnetic components. His early fascination with electricity generated the sparks necessary for the start and growth of Schott Corp.

In 1934 Schott graduated from the University of Minnesota with a degree in electrical engineering. It was not easy being a college graduate during the height of the Depression. "Big companies didn't even bother to come around" to recruit students then, Schott recalls. Only two in his class found engineering jobs that year. He was not one of them. Instead, he worked at a variety of jobs—tool-room machinist, punch-press operator, thermostat installer—until the economy improved. In 1940, he started his first job as an engineer for the Audio Development Co. (now ADC Telecommunications). From 1946 to 1951, Schott worked as an engineer for Telex Corp.

During that time, Schott spent evenings and weekends tinkering in his basement. He did everything from building amplifier systems for bands that played at the University to designing a component for a linear accelerator.

He also built some amateur radio transmitters for engineers at the University, and developed some transformers to provide power for a remote materials handling device designed by some engineers at General Mills. The projects "all pretty much involved special applications in electronics," he says.

They also had become so time-consuming that Schott knew he couldn't do justice to his work at Telex and also meet the other demands. So in 1951 he moved from his basement to a building on Aldrich Avenue in Minneapolis and started his own corporation.

"My original idea in a business was to have a small group of 25 to 30 people. I thought that would be a nice group. I quickly discovered this was fine to meet the requirements for new items. But unless I was able to take care of follow-up needs, I couldn't do engineering and development." The company has continued growing to meet an ever-increasing demand for its power supplies.

Today, Schott Corp., headquartered in Wayzata, Minn., employs 350 people in several locations. The company uses a plant in Canby, Minn., for larger production runs. One in Marshall, Minn., manufactures smaller units, while a third plant, in Minneota, Minn., handles what Schott calls "more sophisticated" projects. Recently, Schott incorporated a separate business on the Caribbean island of St. Kitts in a move to remain competitive with Mexican and Far Eastern manufacturers.


Oscar Schott

Over the years Schott Corp.'s power components have been used in Control Data computers, Cray supercomputers, IBM products, and even in electric nutcrackers. Schott's magnetic components have traveled on Skylab, and its power components have gone to the moon. In fact, Schott provided power components for every one of the U.S. space program's Apollo missions. For the Apollo program, Schott Corp. developed a product that converts the power of different voltages and currents to match the requirements of various spacecraft instruments.

Since Schott's retirement nine years ago, his son, Owen, who graduated with a degree in electrical engineering in 1965, has been CEO. Schott's other son, Wendell, recently joined the company as vice president in charge of administration.

Now that he has left the day-to-day operation of the corporation to his two sons, Schott is free to roam. Much of his time away from the board room is spent in a motor home, traveling with a motorcade club. Every year the club has winter and summer conventions to places such as Fairbanks, Ala.

As long as fresh water and waste disposal are available, no place is too remote for the group—especially because the motor homes have their own generators, he says. And with Schott along, those generators are likely to produce as much power as anyone needs.

By Miriam Feldman

1944

Harry J. Foehringer *(Mechanical, 1947 M.S.)* retired after 35 years with TRW, Cleveland, Ohio. He was group operations director at TRW and had previously worked for General Electric and the Bureau of Labor Statistics. He is now a consultant.

1950

David B. Ballou *(Mechanical)* retired from the United States Air Force as a colonel in 1987. He was recalled to active duty with the Minnesota Air National Guard during the Korean War and spent 31 years in the Air Force as a fighter pilot.

1953

Frank T. Manheim *(Geology, M.S.)* is studying United States use of oceans while on sabbatical leave from his job at the U.S. Geological Survey in Woods Hole, Mass. A grant from Olin Foundation and the State University of New York at Stony Brook funds his study.

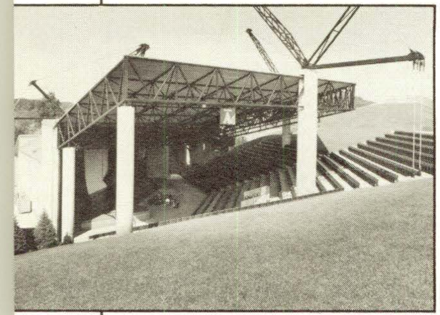
1955

Howard B. Hamilton *(Electrical, M.S.)* retired as professor emeritus at the University of Pittsburgh, where he served as chairman of the electrical engineering department from 1966 to 1973 and from 1985 to 1986. He is currently a consulting engineer.

1960

Wayne C. Larson *(Civil and Mineral)* and colleagues **Nick Pitera** *(1983, Civil and Mineral)* and Kevin Cole won a 1987 Silver Award from the James F. Lincoln Arc Welding Foundation for their design of the "Ironworld U.S.A. Amphitheater Audience Canopy." Larson is president of Larson Consulting Engineers, White Bear Lake, Minn., and Pitera and Cole are structural engineers there. They solved the problem—providing an open, airy atmosphere to complement the landscape without letting canopy support columns obstruct the audience's view of the stage—

by supporting the 110,000-pound roof with four stationary crane structures of welded tubing and a long-span truss system.



Ironworld canopy

1961

William E. Pederson *(Architecture)* designed Lincoln Centre, a new building at Seventh Street and Fourth Avenue South in Minneapolis known for its glowing tower. A partner in the firm of Kohn Pederson & Fox, New York, N.Y., he was recently named a fellow of the American Institute of Architects.

1977

Henry W. Voth *(Civil and Mineral)*, **Kesh Ramdular** *(1979, Civil and Mineral)*, and **Wayne C. Larson** *(1960, Civil and Mineral)* won a 1987 Bronze Award from the James F. Lincoln Arc Welding Foundation for their design of "Safaga Ship Unloading Gantries." Voth and Ramdular are structural engineers at Larson Consulting Engineers, White Bear Lake, Minn., and Larson is the company's president. Their 140-foot-tall, tower-like structure extracts grain from ships at the Red Sea port of Safaga, Egypt.

1980

Geneva M. Omann *(Biochemistry, Ph.D.)* holds a joint appointment as assistant professor of surgery and biological chemistry at the University of Michigan Medical School in Ann Arbor, Mich.

1982

Mark C. Joyce *(Mechanical)* is a senior product development engineer with TRW Vehicle Safety Systems Inc., Washington, Mich., a leading manufacturer and designer of automotive restraint systems. He was formerly a test engineer with Oldsmobile.

David S. Olson *(Civil and Mineral)* is a structural engineer in the electric boat division of General Dynamics Corp., Groton, Conn. He married Elizabeth Anne Cameron, also a civil engineer at General Dynamics, in Oct. 1987.

Thomas R. Sand *(Electrical)* is an engineer at IBM Corp. in Rochester, Minn.

1985

Jason Ball *(Chemical)* is a plant engineer for Cargill Inc. and an MBA candidate at Pepperdine University, Malibu, Calif.

Steven W. Lee *(Aerospace)* is a design and development engineer at Honeywell Inc., Clearwater, Fla. He works on space station attitude control system design and flexible body analysis.

Nga-Alexia Q. Makousky *(Electrical)* is a system engineer for the Boeing Co., Seattle, Wash.

1986

Martin C. Thomsen *(Mechanical)* is a mechanical engineer in new product development and research at Oceanic U.S.A. in San Leandro, Calif.

1987

Biswajit Dasgupta *(Civil and Mineral)* joined the University's Underground Space Center (USC) as a research associate studying vibrations of underground mined space caused by disturbances on the earth's surface. While completing his Ph.D., he worked at the USC as a research assistant.

Jack Tsai *(Civil and Mineral)* is a computer science student at Polytechnic University, Brooklyn, N.Y.

1988

James D. Peterson *(Electrical)* lives in Des Moines, Wash., and is an electrical engineer for Boeing Advanced Systems Co.

ALUMNI NEWS

Reunion festivities at homecoming

The Institute of Technology class of 1928 and all previous classes will celebrate their 60th-plus reunions, coinciding with the 50th-reunion festivities of the class of 1938, at the University's fall celebration, "Homecoming: There's Just One 'U.' "

IT 50th and 60th-plus Reunion Tentative Schedule

Wednesday, Oct. 5:

- reception hour, 6:00 p.m., Radisson University Hotel, 615 Washington Ave. S.E.
- reunion dinner with guest speaker, 7:00 p.m., Radisson University Hotel

Friday, Oct. 7:

- IT department open houses (coinciding with the all-campus open house), 8:00-11:00 a.m.
- 1938 civil engineering dinner, 6:30 p.m., Golden Valley Country Club

Homecoming Tentative Schedule

- Gopher Sportacular (date to be announced)

Thursday, Oct. 6:

- U.S. presidential or vice-presidential candidate debate at Northrop Auditorium

Friday, Oct. 7:

- spouse tour of the Twin Cities and lunch
- homecoming extravaganza
- homecoming parade, bonfire, and fireworks

Saturday, Oct. 8:

- homecoming pepfest
- homecoming football game (Gophers vs. Northwestern at the Metrodome)

All alumni are welcome to attend homecoming. For more information, write to: Linda Goertzen, IT External Relations Office, 107 Walter Library, 117 Pleasant St. S.E., Minneapolis, MN 55455; or call 612/624-1030.

Job guides available

Alumni can receive free copies of the *Career Opportunity Index* and the *Career Opportunity Update.* Published by Career Research Systems Inc., the index profiles major employers who regularly seek job candidates. The update lists career opportunities nationwide by occupation and company, gives current information on job openings, and features salary surveys, job-search information, and technology trends. To receive complimentary copies of these publications, write to: Career Research Systems Inc., Attn.: Alumni, P.O. Box 8969, Fountain Valley, CA 92728-8969. Include your job title, university, years of experience, and address.

Parks awarded alumni scholarship

The Beta Chapter of Kappa Eta Kappa Alumni Association awarded its 1987-88 John H. Kuhlmann-Kappa Eta Kappa Scholarship to Kevin Parks. Parks, an electrical engineering senior, won the $1,500 scholarship for scholastic achievement and service as an engineering student and as a Kappa Eta Kappa member.

The annual scholarship program began in 1986 and has continued under an endowment program in memory of electrical engineering professor John H. Kuhlmann, a founding member of the Beta Chapter of Kappa Eta Kappa who died in 1984.

FACULTY

Agricultural Engineering
Professor ***Roger E. Machmeier*** received the 1987 Gunlogson Countryside Engineering Award from the American Society of Agricultural Engineers.

Chemical Engineering and Materials Science
Professor ***James R. Chelikowsky,*** an internationally recognized theorist on the structure and electronic properties of solids, joined the department in winter 1988. Chelikowsky and professor ***John S. Dahler*** were recently elected fellows of the American Physical Society. ***H. Ted Davis,*** professor and department head, was elected a member of the National Academy of Engineering. ***José Martins,*** assistant professor, joined the department in fall 1987. Professor ***Lanny D. Schmidt*** received the Fairchild Distinguished Scholar Award from California Institute of Technology. ***Dave Shores,*** associate professor, was elected senior vice chair of the Electrochemical Society's High Temperature Materials Division. Professor ***Matt Tirrell*** was elected a fellow of the American Physical Society in December. ***Robert T. Tranquillo,*** assistant professor, was a NATO postdoctoral fellow at the Center for Mathematical Biology, Oxford University, before he joined the department in September 1987. Professor ***John Weaver*** is vice-chair of the American Vacuum Society's Surface Science Division, executive committee member of its Electronic Materials and Processing Division, and a steering committee member of the Argonne National Laboratory's Advanced Photon Source Users Organization.

Chemistry
Professor ***William Ronald Gentry*** was elected a fellow of the American Physical Society. The University awarded ***Steven Kass,*** assistant professor, one of nine McKnight-Land Grant Professorships for 1988. The three-year professorships include yearly $16,500 research grants designed to boost the careers of promising junior faculty and to encourage them to remain at the University. Professor ***Essie Kariv-Miller*** was granted a Bush Sabbatical by the University.

Civil and Mineral Engineering
Catherine French, assistant professor, received an award for outstanding service as the 1986-87 advisor to the student chapter of the American Society of Civil Engineers (ASCE). Professor ***Ted Galambos*** received the University of North Dakota Alumni Association's Harry Nyquist Award for outstanding contributions to engineering. St. Anthony Falls Hydraulic Laboratory (SAFHL) professor ***Charles C.S. Song*** was elected a vice president of the International Research Center on Hydraulic Machinery's executive committee and joined the editorial board of the *International Journal of Engineering Fluid Mechanics.* ***Heinz Stefan,*** professor and associate director of SAFHL, was appointed to a three-year term on the ASCE National Energy Policy Committee. ***Yorgos Stephanedes,*** associate professor, was named vice-chair of the new ASCE Committee on Advanced Technologies in Urban Transportation.

Computer Science
Assistant professors ***Ravi Janardan*** and ***Haesun Park*** recently joined the department. Professor ***Sartaj K. Sahni*** was named a fellow of the Institute of Electrical and Electronics Engineers.

Geology and Geophysics
Professor ***Subir K. Banerjee*** spent spring quarter 1987 as visiting scientist at the National Geophysical Research Institute in Hyderabad, India. He convened a National Science Foundation workshop on rock magnetism research in Asilomar, Calif., and received a certificate of appreciation from the Engineers Club of Minnesota for taking part in their visiting speakers program. ***Priscilla Grew,*** professor and director of the Minnesota Geological Survey, has been elected to a two-year term on the Council of the Geological Society of America. Professor ***Roger L. Hooke*** is a member of the Council of the International Glaciological Society. Professor ***Paul W. Weiblen*** is the North American editor of *Mineralogy and Petrology.* A May symposium on Quaternary landscapes honored ***Herbert E. Wright, Jr.,*** regents' professor and Limnological Research Center director.

Mathematics
Bernardo Cockburn, assistant professor, joined the department last fall and specializes in numerical analysis. ***Henrik Egnell,*** from the University of Uppsala, Sweden,

Faculty *to p. 16*

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DEATHS

William N. Carey, Jr. *(Civil and Mineral 1937),* 72, retired executive director of the National Academy of Sciences transportation research board. A native of St. Paul, Minn., he served in the Army during World War II and attained the rank of lieutenant colonel. In 1946 he joined the academy in Washington, D.C., and in 1973 he received its Distinguished Service Award. Carey was a member of the American Society of Civil Engineers and the board of the National Safety Council. He received the University's Outstanding Achievement Award in 1977.

Fred D. DeVaney *(School of Mines 1923),* a consulting research metallurgist.

Richard W. Jones *(Electrical 1926),* professor emeritus of electrical engineering and biological sciences at Northwestern University, Chicago. After his graduation from the University of Minnesota, he worked for Westinghouse Electric Elevator Co. as a design and development engineer, obtaining several patents in the field of elevator control systems. In 1941 he earned a master's degree in physics from Northwestern and taught there from 1942 to 1971. He developed courses in biological and physiological control systems that led to the creation of Northwestern's department of biomedical engineering. The author of two books, he received an Alumni Merit Award from Northwestern.

Joel McCracken, a junior in the University's civil and mineral engineering department. The department and college will confer his degree posthumously.

Dick Wiezel, principal lab machinist in the chemistry department's machine shop for many years.

***Faculty** from p. 15*

will be the 1988-91 Dunham Jackson Instructor.

Mechanical Engineering

Professor ***Arthur Erdman*** and assistant professor ***Thomas Chase,*** with alumnus Greg Marier, won a merit award at Oklahoma State University's 10th Applied Mechanics Conference. ***Subbiah Ramalingam,*** professor and director of the Productivity Center, was awarded the 1988 Society of Manufacturing Engineers Frederick W. Taylor Research Medal for outstanding published research on improving manufacturing processes. Professor ***Ephraim M. Sparrow*** received the National Science Foundation Federal Engineer of the Year Award in February.

LETTERS

In commemoration of Dr. Harold Mooney, professor of geophysics, who died last year, this old student should like to pass on a few comments.

Mooney was a well-prepared and committed teacher. He also had a puckish sense of humor and a rare personal humility (rare among professors, that is).

During a recent visit to my "ancestral" home in Kansas City, I found my class notes to "Geophysics 108" (General Geophysics), from the year 1953. Among the discussions of the precession of the equinoxes as measurements of the Earth's bulge, I had recorded some typical Mooneyisms:

- "That's a terrible question to ask!"
- "I don't think so, but I don't know why."
- "It is possible to perform this analysis by a method I am not only unwilling to explain, but do not even understand."
- "And that was the Grand Finale of the discussion of the Figure of the Earth!"

During undergrad years and grad school I more or less assumed that professors were oracles and knew everything. After I got my Ph.D. and went into research myself, I began to realize that university faculty are nothing but grad students dressed up in professors' raiment. So whereas at Minnesota I regarded Mooney as funny but maybe not as smart as other professors, I now realize he may have been wiser, and had the self-esteem that allowed him to reveal his humility.

Frank T. Manheim
1953 M.S. Geology

ITEMS

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