Spring 1991

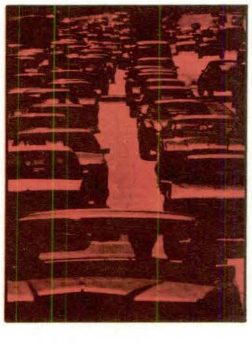
ITEMS

UNIVERSITY OF MINNESOTA
INSTITUTE OF TECHNOLOGY

Stuck in a jam!

Can America afford to maintain its infrastructure?

p. 8



Features

Departments

ITEMS

University of Minnesota
Institute of Technology

Spring 1991

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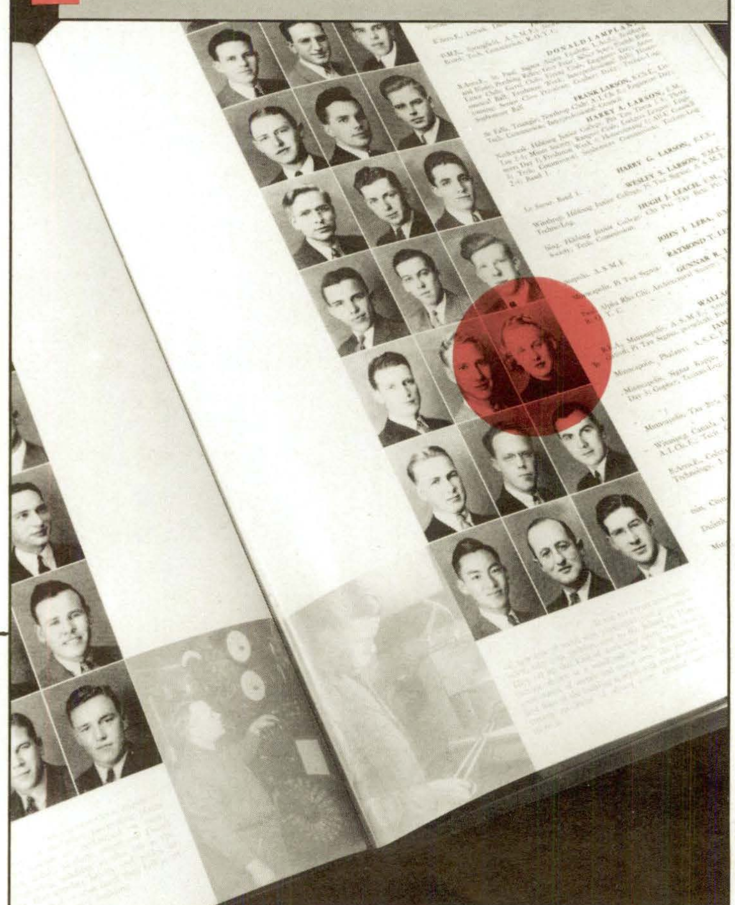
Items is published three times a year to inform Institute of Technology alumni and friends about news, interesting alumni and faculty, and relevant issues. Letters to the editor, requests to receive *Items*, and notices of address changes should be sent to the Office of External Relations, Institute of Technology, 107 Walter Library, 117 Pleasant St. S.E., University of Minnesota, Minneapolis, MN 55455 or call John Watt, 612/626-1804. *Items* welcomes letters and ideas from all readers.

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

About the cover: Americans already spend some 2 billion hours annually stuck in traffic jams. By the year 2005, that figure may quadruple if we don't solve our infrastructure problems. The cover photgraph depicts rush hour traffic in Chicago. Photo by R. Hamilton Smith (Frozen Images).

NEWS



Mystery woman revealed

Our cover story for the spring 1990 issue of *ITEMS* addressed the problems women face in science engineering and the need to attract more women to these disciplines. To illustrate the story, we chose two pages from the 1939 edition of *The Gopher*, the University of Minnesota yearbook. Accompanied by row upon row of male faces, the lone woman pictured on those pages seems lost. But Mary Jean (Lindsey) Angermeyer is not the sort to let herself get lost, even though she was the only woman in her 1939 graduating class of some 35 civil engineers. And, judging from the calls, letters, and copies of the article she received from friends and classmates after the story appeared, she will not soon be forgotten.

The isolation Angermeyer faced as the sole woman in her classroom was countered, on advice from her mother, by joining Sigma Kappa sorority. "Mother was concerned I would not be enough involved with women," Angermeyer says. "The sorority and the female friends I made there helped me a lot. But how I wish some of those women [mentioned in the article] had been around IT when I was there!"

Life in the classroom was sometimes awkward for Angermeyer. Occasionally professors made jokes—or refused to tell stories—because Angermeyer was present. "Everyone would turn around and look at me," she says. "I was kind of shy and I would turn beet red." Beyond those few occasions, however, Angermeyer says her classroom experience was pretty normal and feels she was always treated fairly when it came to grades. "We were a fairly close class and got to know each other quite well. I think the guys all accepted me," she says.

When she couldn't get the help she needed from her classmates and sorority friends, Angermeyer had her own support network within her family. Her father was a civil engineer, and her mother was a math teacher. All of her siblings attended IT as well. Her brother, Jim (pictured to her left in the yearbook photographs above), received his bachelor's degree in civil engineering in 1939. Another brother, Ray, followed in their civil engineering footsteps, graduating in 1943. Her sister, Ethel Mae, received her bachelor's degree in interior architecture in 1941.

After graduation, Angermeyer worked in several areas, including packaging design for Kimberly Clark for three years, before taking time out from her career to give birth to and raise four daughters. In 1960, when her daughters had grown, she went to work at her husband's plumbing, heating, and mechanical contracting firm, doing both estimating and design work. She and her husband, Howard, retired in 1972 and have been living in the lake country northwest of Green Bay, Wis. They are planning to move to Oshkosh this spring.

None of Angermeyer's four daughters followed in her footsteps, though all received their college degrees—in education, home economics, physical therapy, and art. Angermeyer is not disappointed ("They're all great girls. I wouldn't change a thing!"), but she is concerned about the challenges women face in the work place today.

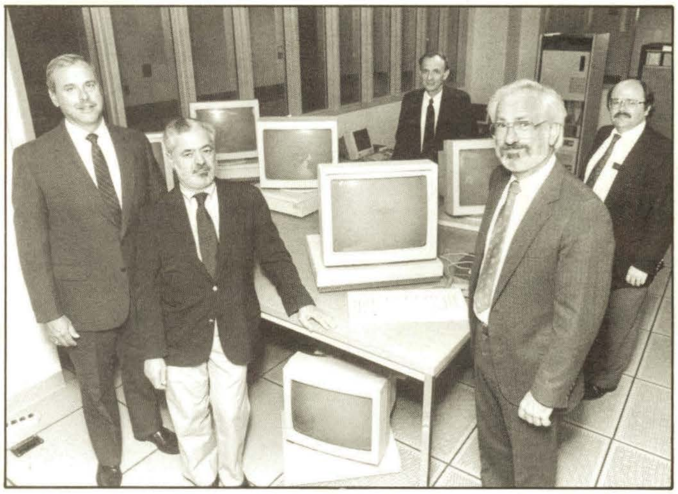
Mary Angermeyer, at the time of her 50th reunion.

"Women are not allowed to go to the top as fast as men," she says. "And, for those women who choose to raise a family, it's very difficult to deal with the interruption to their careers."

Despite the obstacles, Angermeyer is encouraged by the changes she sees. "Women have made lots of progress since I was active in my career," she says. "For one thing, there's not as much difference in salaries between men and women."

And, although men still outnumber women by more than five to one in IT, women no longer face the degree of isolation Angermeyer did. The "lone woman" in the classroom is a thing of the past. I

Pictured above are IT's Cyrus Scholars. The Cyrus Scholarship was established by Richard Hanschen to support IT students from the Cyrus, Minn., area. The scholarship is unique in that it supports students from the beginning of their undergraduate studies through the completion of their master's degrees. Back row (left to right): Darin Jenson, Mr. and Mrs. Richard Hanschen, and Devin Mix. Front row: Jeremy Jenum, Alan Estenson, Timothy Dorweiler, and Kim Harris.



Cray Research recently donated 30 Sun-3 Workstations to the Computer Science Department. Attending the presentation ceremony were (left to right): Richard P. Hoppe, Cray Research; IT Dean Ettore Infante; Associate Dean Gordon Beavers; John Champine, Cray Research; and Larry Dunn, Computer Science.

You told us so

"More news about our former classmates and their accomplishments."

"More stories about the Institute of Technology's involvement with and contributions to industry."

These were among the most frequently offered suggestions for improving *ITEMS* by the more than 650 readers who completed the survey included in our fall 1990 issue. Your responses have revealed some astounding facts.

Prior to the survey, informal IT records indicated some 50 companies had been founded by IT alumni. Through the survey, we learned, that more than 175 companies have been founded by IT grads—and the list continues to grow. Next issue, you will meet many of those business founders and learn the secrets to their success as our cover story introduces some of IT's most successful entrepreneurs.

In the Alumni Department of this issue—which has been expanded in response to the survey results—we have profiled five IT grads and compiled more than 200 brief updates on some of your classmates.

We're anxious to have your input. If you didn't return the survey in the last issue, dig it up, fill it out, and send it in. Or, you can use the "News About You" form in the back of this issue. Whether you founded a new company, received a promotion or award, or gained a new family member, we—and your former classmates—want to know. I

Left to right: University President Nils Hasselmo, Jack Braun, IT Dean Ettore Infante.

Left to right: Steven Crouch, Richard Braun, Miles Kersten, Dave Holt, and Bud Hayden.

Newly endowed chairs

IT recently commemorated the establishment of two newly endowed chairs: the J. S. Braun/Braun Intertec Professorship in Science and Technology and the Minnesota Surveyors and Engineers Society (MSES) Miles Kersten Land Grant Chair in Civil Engineering.

The Braun Professorship, commemorated November 26, 1990, is an interdepartmental chair that will attract outstanding visiting professors for special lectures, teaching, and research. The professorship has been endowed by Braun Intertec (formerly Braun Technologies Group) and J. S. (Jack) Braun, CEO and founder of the company.

"In endowing the professorship, we are taking a rather innovative approach by cutting across departmental boundaries to support the varied disciplines needed to resolve environmental and engineering issues," said Braun. "We think the creation of the visiting professorship will enhance the University's ability to educate the scientists needed to resolve these complex issues."

Braun Intertec is composed of companies that provide engineering, environmental, and pavement consulting and testing services.

The MSES Miles Kersten Chair, which was commemorated at a luncheon on October 9, 1990, will strengthen IT's programs in pavement engineering, roadway materials, soil mechanics, foundations, and related environmental considerations. The chair was endowed through MSES and contributions from several organizations and private donors. I

Noted

Six students began working in the Minnesota Supercomputer Institute (MSI) Undergraduate Internship Program in Scientific Computing and Graphics winter quarter. The program offers paid internship opportunities on a quarterly basis and during the summer. The student interns for winter quarter are: Devin Crawford, electrical engineering; Paul Mohr, aerospace engineering and mechanics; Matthias Schabel, chemical engineering and materials science; Bradley Hill, civil and mineral engineering; and Connie Lausten, geology. ■ The Microelectronics and Information Sciences Center (MEIS) has been renamed Microelectronics Laboratory for Research and Education (MLRE) to better reflect the laboratory's new mission. ■ The Computer Science Department recently received a grant from 3M in the amount of $9,000 to support basic research and an unrestricted grant from the Motorola Foundation in the amount of $7,500. ■ The IT libraries recently added to its collection part of the industry standards collections of the James J. Hill Reference Library. The Minnesota Section of the National Standards Engineering Society presented IT Libraries with a financial contribution to recognize and support IT's efforts to enrich the resources available to students and faculty. ■ The Center for Transportation Studies is sponsoring the Second Annual Transportation Research Conference to be held May 7-8, 1991, at the Radisson Hotel in St. Paul. For more information, contact Maria Juergens at 612/625-4346. ■ An interdisciplinary faculty group led by Regents' Professor Margaret Davis has received a five-year, $1.4 million grant from the National Science Foundation for a study of "Paleorecords of Global Change." I

ITAS banquet features CIE

D. Fennel Evans, director of the Center for Interfacial Engineering (CIE), delivered the keynote address at the annual Science and Technology Day banquet and Institute of Technology Alumni Society (ITAS) annual meeting, held October 25 at International Market Square in Minneapolis. More than 500 alumni, business representatives, and friends of IT attended the banquet.

In his address, Evans recounted recent successes for CIE and outlined the center's vision for the future. CIE, which is a cooperative research partnership of IT, major technology-based companies from throughout the U.S., and the National Science Foundation, is world renown for its leadership in the emerging field of interfacial engineering.

Other speakers on the program were IT dean Ettore Infante; Tom Rusch, ITAS president; Sue Bennett, national president of the Minnesota Alumni Association; and Barbara Timm-Brock, president-elect of ITAS.

The banquet is sponsored by ITAS. Proceeds help support scholarships for IT students. Alumni interested in joining ITAS can call the Minnesota Alumni Association at 612/724-2323. I

VIEWPOINT

A new agenda for scientists and engineers

By James J. Renier

CEO and Chair
Honeywell, Inc.

(Excerpted and adapted from Mr. Renier's graduation address at the Institute of Technology on June 1, 1990.)

Thirty-two years, seven months, and 27 days ago, a significant technological event occurred. A single object—not very big and not very impressive, resembling a beach ball with some radio antennas from a 1957 Chevy—made its debut. It was called Sputnik—the first artificial satellite. At least the first one from Earth.

Sputnik created an enthusiasm for technologists that lasted for a couple of decades. Since then, this enthusiasm has begun to fade somewhat. I would like to stress the need to rekindle that interest and the need for professionals to bring much more than their technical specialty to society and the world.

The State of Technology

Many thoughtful people are worried about the state of technology in the United States. Their concern boils down to this: Technology is not as highly regarded or considered to be as relevant as it used to be. And it does not wield the influence it once had.

The evidence is all around us. Here are a few observations:

- When I meet with chief executive officers of United States companies, I am often the only person in the room with technical training and experience. This is not true of my peers in Germany and Japan—our chief international competition.
- In 1986, almost half the patents issued by the Patent Office of the United States went to foreign nationals. The next year, the three companies that received the most patents were Cannon, Hitachi, and Toshiba.
- American universities now award more Ph.D.s in engineering to foreign students than to Americans. Although I am very pleased to see foreign students availing themselves of education in this country, one must wonder about the shift that has occurred and the reason for it.

In this country today, our disenchantment with science apparently begins long before college. American students, at the age of 10, rank seventh in a field of 15 countries in terms of scientific knowledge. By age 15, they rank fifteenth out of 16. Our top one percent of physics students ranked tenth and were thirteenth in chemistry.

High-tech businesses are vital. They provide real value added to our economy. Engineers and scientists should run them. It's just plain horse sense that it should be easier to train engineers to become business people than the other way around. But when young people think of business, they think of MBA, not R&D. School kids today are more likely to select their role

VIEWPOINT

models among lawyers and deal makers than among scientists.

Today, there are several reasons technology in the sense of role modeling seems to have fallen from grace. For one thing, sad to say, the benefits of technology are often most evident in time of war. During World War I, technical experts turned aviation from tinkering into science. In world War II, they developed rocket propulsion and radar. Jet engines, which came out of this period, were thought to be strictly for military planes. Now they are the keystone of one of the few industries in which America still holds dominance in world trade. All of this was impressive in war time, but now the public image of the high-tech defense industry is not at a high.

In recent years, it has been alleged that technologists have produced as many problems as they have solved. Many things are cited—noise, hazardous wastes, global warming, nuclear dumps, and war material—just to mention a few. Even in the medical field, technologists are being accused of developing expensive techniques that we cannot afford to use.

In addition, the emphasis of the 1980s distinctly turned toward finance and away from the value-added and long-term endeavors of science. Many seemed determined to cash out in the short term on what technology had built, rather than go on building. Emphasis moved to a service economy.

The challenge

The greatest potential contribution of engineers and scientists to society is your willingness to search for truth, not shortcuts to wealth; your motivation to build value, not just trade assets; your ability to apply analytical thinking to the scientifically softer but much more complex problems of mankind and society, not just to deal with problems that yield to simplifying assumptions. Furthermore, to gain recognition, this ability must be applied to the whole host of new problems that preoccupy society, not just your science.

When federal budgets were balanced and U.S. business was king, a haven was created for the traditional roles of the scientist and engineer. Funds were plentiful. Today, R&D budgets are diminishing, federal and state budgets are coming under more pressure, social problems are severe, and a seeming lapse in ethical business behavior has descended upon us. Things are not the same—there is no longer any haven for technology, neither in industry nor government.

These factors not only impact a project that you may envision, they threaten your ability to even conceive the program that could contain your project. You have to act as if you care. What kind of role model does the technical profession advertise if it delegates these problems and asks to be left alone?

Let me give you an example. No one can say how much the savings and loan fiasco will eventually cost this country—estimates range up to half a trillion dollars. But it is clear that at least $100 billion have been squandered, as one commentator put it, on mansions and yachts and hidden away in Swiss banks. Imagine what we could accomplish if that $100 billion had been invested in technology for more efficient factories or steel mills, or in research to reduce pollution or improve education. Is this not your concern? Is this really none of your business?

It's time for technical people to participate in policy making, to help run their companies, help set our direction in government and public affairs, and establish new, ethical role models.

It goes without saying that an organization, wherever you work, can use the benefit of your training and creativity in setting strategies. The rest of society needs your disciplines and analytical judgment in helping to resolve some of its gut wrenching national issues. More professionals in technical fields have to stand up and say, "I want to help run the show." And that means they have to come out of the lab and step onto a larger stage. When technologists grow beyond their discipline and become its champions and ambassadors, not just its practitioners, they accomplish more for the world and more for their science.

Arnold Toynbee said, "Technological wizardry is not an end in itself. It is desirable only if it makes for human welfare, and this is the test that any tool ought to be made to pass. Your wizardry and issues of human welfare are at the crux of my message. Let me briefly describe some of these issues

The first issue involves our ability to compete in a global economy. In 1987, the gap between exports and imports reached the point where our trade deficit equaled the entire U.S. economic output for the year 1943. In every year from 1894 to 1970, we had a trade surplus. In 1970, the tables began to turn. Why?

A quick answer is productivity. Since 1950, our productivity has grown only about one-and-a-half percent a year, on average. Meanwhile, Japan has grown about six percent a year and West Germany, four percent. Hard work and scientific initiative have served these countries well.

Japan was quick to adopt statistical process control when it was introduced there in the 1940s. The technique was developed by an American, Dr. W. Edwards Deming, who was brought to Japan by General McArthur immediately following the Second World War. In 1951, just a few years after Deming arrived, the Japanese established their highest honor in industry and named it after him: The Deming Prize. It was not until the late 1970s—almost 30 years later, when Americans were forced to consider quality and productivity—that Deming's methods were recognized in this country.

If we want to increase our ability to compete—indeed, if we want the American economy to survive as we know it—technically trained people are going to have to take a bigger hand. Can each of you make your work so relevant to industry and society that you capture the imagination of young people who are seeking role models? Can you show them that your profession has sufficient span to include the problems we face as a nation? They need to admire what you bring to the party in this competition for the world's markets.

Then there is the vexing problem of the growing stress on American families and its effect on children. For 20 years, there has been an increase in the number of American families in which both husband and wife go to work outside the home. They have to; if they didn't, 35 percent more families would be living below the poverty line. We used to think the normal household was a father who works and a mother who takes care of the household and the kids. Today, that describes less than four percent of American families.

The impact on children is heavy. By 1995, two-thirds of all preschool children and three-fourths of all school-age children will have mothers in the work forces. How can kids get the parental training and background to be productive, responsible citizens when both parents have full-time jobs?

Too often, they can't. And it's showing up in education. About 29 percent of students who enter American high schools fail to graduate. And they cost this country about $240 billion over their lifetimes in lost wages and unpaid taxes.

Educational disadvantage strikes hardest on the children of the poor. One out of every four youngsters lives below the poverty line. Recent research suggests that about one percent of all children feel there are no adults who really care about them. But for poor children, the number is seven times higher. Poor children are more likely to feel the pressure for destructive behavior, three times more pressure to take drugs, twice more to disobey authority, four times more to join a gang, and half again as much to have sex.

We can help these kids most by making sure they get the care they need from conception onward. In spite of the generous return on investment in education, we invest but a meager pittance to modernize and improve the educational process. A comprehensive report by an authoritative think-tank shows that the problem is not one of spending too little. It is one of spending on the wrong things. We spend too much on obsolete and disproven practices, and not nearly enough to develop innovative and effective methods.

The average U.S. business spends two percent of its revenues on R&D; in many high-technology businesses, it is seven to 20 percent. Yet, the education establishment invests less than one-tenth of a percent of revenues on research and innovation to make teaching and learning more productive. That is less than $50 a year for each educational employee—the teachers and administrators—compared to $5,000 in a typical business, and over $40,000 in some high-tech businesses.

You as technical professionals should understand, if anyone does, what R&D can accomplish. It should trouble you deeply that we invest so little in the technology of education when education is charged with developing our most valuable resource—our people. What will you do to make education and employment more productive for all citizens?

Finally, I want to challenge your sense of ethics. In a survey of business people, 97 percent said that business is at least reasonably ethical. But 94 percent also said that business has some ethical problems. As you move to areas of wider responsibility, ethical questions will become more ambiguous. Here are some that come up in the course of the average business day.

- In product safety, how far does a company's liability extend? Obviously, a safer product represents higher ethics, but how much should we over-design for the sake of safety and ethical principle?
- Is it ethical for a company to do defense research? If the company does not, can it ethically ask the military to protect the company's assets overseas or defend the company in time of war?
- Does the end justify the means in technical research? Some medical research employing fetal tissue and programs in genetic engineering have already raised ethical questions.

When your career brings you face to face with ethical issues like these, you will find the answers for yourselves. But, let me simply say that as you progress in your careers, you will require more than technical skill. You will also need human understanding, social perspective, and an appreciation of values—wisdom, if you will.

If we want the American economy to survive as we know it, technically trained people are going to have to take a bigger hand.

Are you willing to expand your scope from the concrete and demonstrable world of technology into the ambiguous and speculative world of ethical philosophy? Now that you have mastered the treatises on technology, are you willing to master the 50 great books and the lessons of wisdom that they hold? Will you place your confidence in your own inherent intelligence and inquiring mind, or rely solely on on-the-job training?

Each of these challenges, I believe, is an opportunity for you to use the ability you have already demonstrated to diagnose problems and resolve them. You won't find answers overnight. You will have to be smart, but you will also have to be wise. Remember, technologists like Galileo, Descartes, and Leibniz were also philosophers and impacted society in a broad context. They were excellent role models—why not you?

The University of Minnesota has taken some remarkable steps to combine technical accomplishment with wisdom. The new Center For the Development of Technological Leadership encourages interested students to broaden their education with a curriculum in the humanities and business as well as the hard sciences. Other universities are doing likewise, but this one has an early start.

The program for Integrated Degrees in Engineering, Arts and Sciences provides help for undergraduates who want to take a degree in both a science and one of the liberal arts. The program for a minor in management helps prepare undergraduates with some of the skills they will need as their careers develop. And the Management of Technology, which offers a master's degree, is an opportunity I commend. It is the boldest, most innovative program I know to help seasoned technical professionals master the arts and philosophies of management—the wisdom—that makes a career rewarding, fulfilling, and relevant.

Facing up to and applying our knowledge to the kind of problems we have discussed is what makes technology—or any pursuit—relevant to the community. I am asking technology to adapt to a needed new relevance. The challenges I offer you are tough. In solving technical problems, answers often tend to be either right or wrong. In society, goals are more ambiguous and solutions more elusive.

The nation's promise

Today, this country needs quality science and engineering as never before. And it needs their professionals to become role models for children who cannot see the significance of careers that seem to be aloof and remote from social and economic reality.

Remember my question about whether you would now turn for wisdom to the 50 great books. One of these books is the "Great Book"—the story of the life of the ultimate role model and the clear message that work is not the end in itself, but a means to an end. That end, as described in this book, is not measured by research papers, unique designs, wealth, or power, but by how little children are treated and how well and to what purpose people use their talents. In this book, the case for ethical behavior—at the highest level in all that we do—is irrevocably stated.

I am confident that our brightest minds, engineers, and scientists can return this nation to its full promise if they feel a responsibility and have the desire to do so. And those who are a part of doing so will know they played a role in the major themes of the 21st Century. In participating, each of you will win the respect of those around you. And, you will build a richer career for yourself. Most important, I can promise you this: You will achieve the only valid objective for a career: helping to recreate a society that offers more to its people and more to the people of the world. In so doing, the profession will also assume its deserved place. I

Big brother (IT Civil Engineering senior Jay Chiglio) is watching! This bank of monitor's in Mn/DOT's traffic control center helps control traffic flow on metropolitan freeways. Chiglio works part time at the center.

Our crumbling foundations

America's infrastructure—especially ov
state of disrepair. I
piece

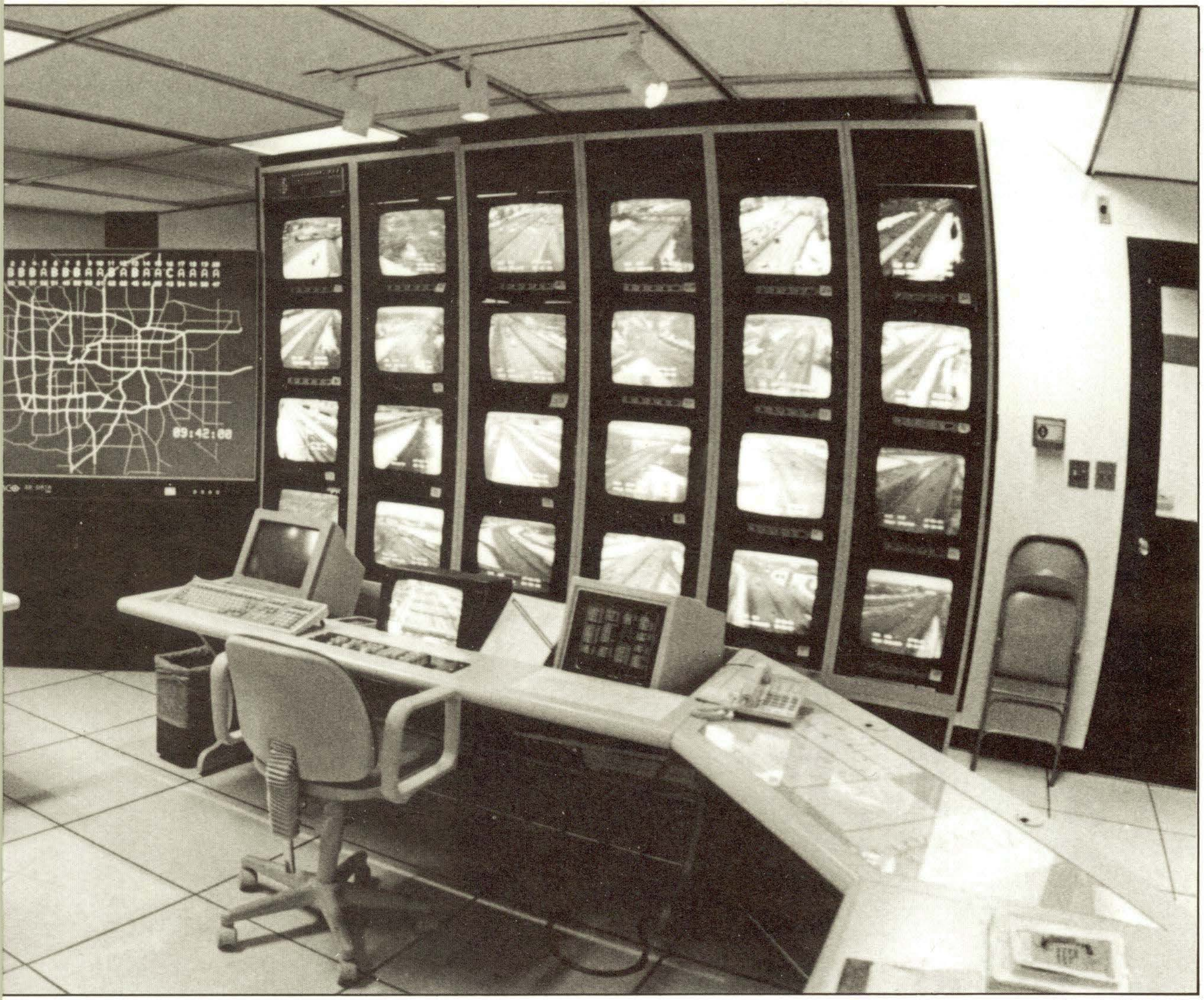


Photo by Rob Levine

By Maggi Aitkens

Most of us are guilty of it; it has become something of the American Way. We consciously stretch our budgets to the breaking point when it comes to buying a new house, a car, or other property, and then wring our hands in anxiety when unforeseen repairs to those investments later throws any semblance of good financial management to the wind.

In a sense, that's what this country did when it invested in its elaborate infrastructure of highways, bridges, and sewer systems many years ago. The nation left the problems associated with maintenance and replacement to be figured out later.

Although the term "infrastructure" encompasses everything from the sewers running underneath our cities to the planes travelling overhead, the problems are similar in all areas. In a word, they're deteriorating. And in numbers, we don't have the financial resources to make all the necessary repairs or to keep pace with the multitude of changes in society that have placed unforeseen burdens on our original structures.

ransportation systems—is in a precarious cientists are helping ack together.

In spite of the alarm sounded by people-in-the-know, however, no one seems to listen. Americans in most cities, for example, are not aware that when they flush their toilets, there's an equally good chance their sewage will end up in a nearby river, ocean, or groundwater supply as there is of the sludge making its way to a treatment plant. Nor or they aware that with 176.5 million motor vehicles in the United States today, Americans will spend about two billion hours a year stuck in traffic jams because our roadways cannot handle the volume. And, even if we are able to bear the stress of traffic, unfortunately our roadways and bridges can't. They weren't designed to handle the increased weights of our trucks and vehicles or the added use we expect of them.

"Most people don't recognize that within the last couple years they took the last wooden sewer mains out of Hennepin Avenue in downtown Minneapolis, for example," says Richard P. Braun, director of the Center for Transportation Studies at the University of Minnesota. "But it shows you how we've been living off of the past. Vast public improvements were made years ago in the infrastructure, but we didn't maintain those improvements properly over time or have replacement and renovation schedules in place. What's happening is, 'living off the past' is catching up with us right now."

Professors in several departments at the Institute of Technology are helping to change all that by finding ways to crack the problem of our crumbling infrastructure. At the Center for Transportation Studies alone, for example, more than 55 projects are underway that address current trends and issues particular to Minnesota's infrastructure problems.

Since it's clear there will never be adequate funds to meet our infrastructure needs, the primary goal of this research is to find ways to make better use of what we have, as well as design innovative, economical structures that will last longer—particularly in the areas of highways, bridges, traffic problems, and sewer systems.

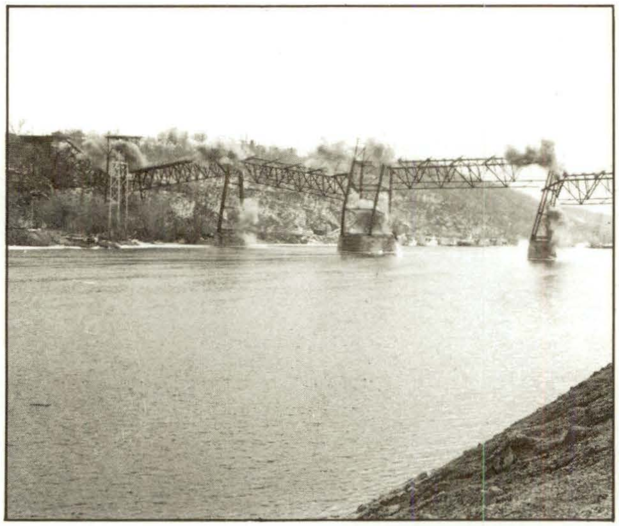
Highways: paving the way

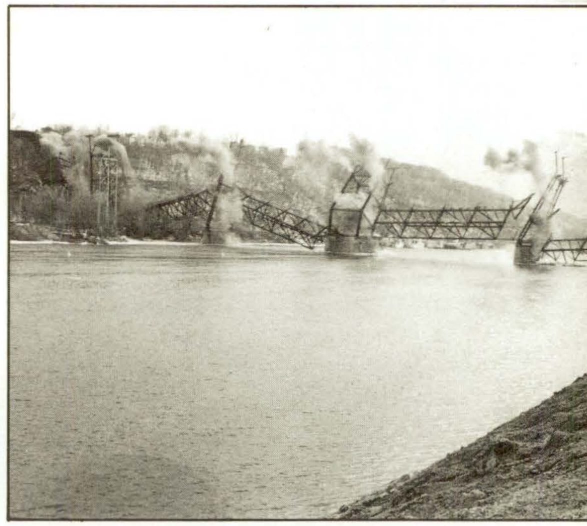
The old adage goes, Minnesota has but two seasons—winter and road construction. Although people in most states will never have to bear the agony of Minnesota's deep freeze, they are nonetheless likely to soon join Minnesotans in a long season of detour dodging—that is, if the money can be found to address the nation's mushrooming problem of deteriorating roadways.

The United States has one of the most elaborate roadway systems in the world, with 3.88 million miles of pavement spanning the nation. Unfortunately, 92 percent of these roads were built prior to 1960, and their expected life runs only about 30 years. At the same time, vehicle miles traveled on the nation's highways have increased 31.9 percent since 1976 to 1.8 trillion vehicle miles, as have vehicle loads—in many cases surpassing the capacity for which the roads were designed. Both of these factors quicken the deterioration process of our roadways. The worst of it is that some experts expect these amounts to double by the year 2005 due primarily to less reliance on rail for transporting products and increasing urbanization in outlying communities.

"Our big, broad freeways stimulated more suburban development than anyone every expected," says Braun. "In Minneapolis/St. Paul, for example, virtually all new housing and over 70 percent of new employment occurs outside the center two cities and first-ring suburbs. What this means is that not only are more people commuting to the city for work, they are commuting from one suburb to another, where there may not be an adequate network of roads in place. As a result, we have a whole set of needs that go beyond our obvious rehabilitation problems."

When it comes to rehabilitation of existing roadways, The Road Information Program, a Washington research group, estimates that 62 percent of the paved highways in the U.S. need some form of rehabilitation at an estimated cost of $164 billion—and that's only for those that are rated in poor to very poor condition. Unfortunately, funding for such repairs is not expanding. Federal highway outlays, for example, increased from $6.1 billion in fiscal year 1977 to $12.8 billion in 1987, barely keeping up with inflation.





Even though Minnesota ranks among national leaders in terms of per capita investment in highways and transportation, some estimate that the Minnesota Department of Transportation's (Mn/DOT) budget of $400 million covers only about half of what is needed to maintain its 12,100 miles of state trunk highways (which accommodate 58 percent of the travel). "What we have to do is try and make things last longer," says Merritt Linzie, director of Mn/DOT's Office of Highway Programs. "Instead of investing in a highway every 40 years, we'll stretch it out to 60, or we'll resurface roads when perhaps we should do a little bit more."

A $1.4 million project currently underway with the help of University professors via the Center for Transportation Studies should help state and federal highway officials get the added mileage they need out of their roads. Known as the Minnesota Road Research Project, researchers will study the effects of weather and traffic on various roadway materials, including soil, base, subbase, and pavement types. Its goal: to come up with better road designs so that as our roads wear out, they can be replaced with longer-life pavements.

Located parallel to Interstate 94 in Wright County, the test facility for this project consists of a three-mile, two-lane test road that incorporates 40 different pavement designs of asphalt, concrete, or aggregate surfaces. Traffic traveling on westbound I-94, which will provide the loadings necessary for the research, can flow from the main freeway onto the test road and back again without interruption. A road with an oval, racetrack-like configuration is also being constructed to research low-volume road designs. Traffic on this road will consist of repeated passes of trucks with known loads and varying tire and axle configurations.

But if test roads and traffic loadings don't excite you much, the other high-tech underpinnings of this project will. An extensive network of more than 3,000 sensors located in, under, and on top of the pavement and tied to a central database management system will monitor each pavement section and collect invaluable data never before compiled. They will record load response parameters such as stress, strain, and deflection; traffic volumes; weights; speeds; and even low water pressure, which is responsible for frost heaves.

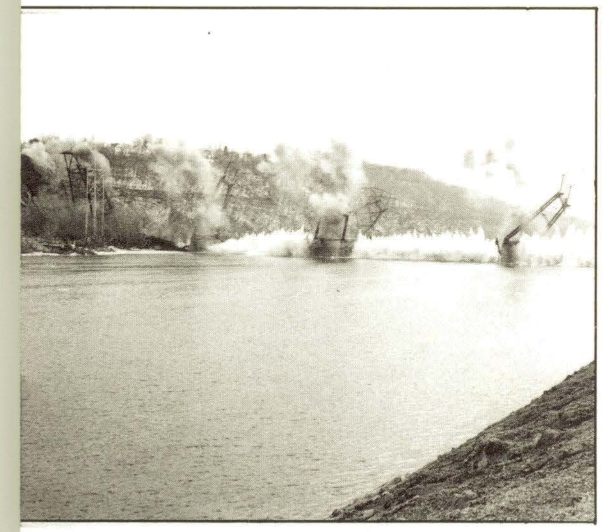
At the same time, an automated weather station will record such environmental factors as wind speed and direction, air temperature, humidity, precipitation, barometric pressure, solar radiation, and ground moisture and temperature at various depths, as well as detect ice, dew, and the presence of deicing chemicals via sensors on the pavement's surface. Finally, a weigh-in-motion scale will take charge of monitoring axle weights, while a nearby axle classification system covers vehicle speed, length, and axle spacing.

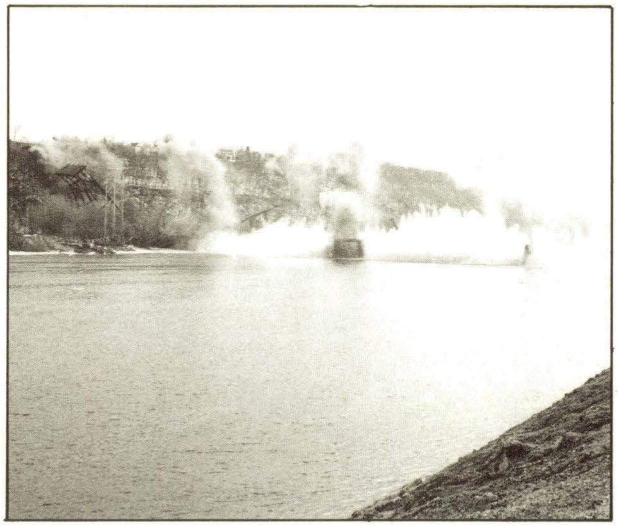
"At this point, we're confident we'll learn enough from the project to improve road design, and that's simply by virtue of the fact that we don't know much about why pavements react the way they do," says Robert J. Benke, manager of Research Administration & Development for Mn/DOT. "We've known for years that if you put a heavy truck load on pavement of a certain type that, sooner or later, it's going to wear out. But little is known as to why, because we haven't had the sensor technology, time, money, or resources to get that information."

Surprisingly, most of the technology used in pavement design today was developed as far back as 40 to 50 years ago as a result of the American Association of State Highway and Transportation Officials' road test, which was conducted as part of the interstate highway program, according to David E. Newcomb, assistant professor of Civil and Mineral Engineering. "Unfortunately, that was an accelerated two-year test that didn't take such factors as environmental effects and traffic loads into account," he says. "What's more, the trucks they used were representative of the times, and a lot has changed since then, including weight, tires, and even tire pressure. All that combined tells you we're still back in the prehistoric age as far as our technology goes."

To answer some of the questions, researchers on the Minnesota Road Research Project are intentionally building some problems into the test sections in order to quantify how much affect they have on the roadway's performance. "We're using two different types of asphalts, for example," says Newcomb. "We know one will perform worse in cold weather than the other, but we want to find out how much worse. We're also building in problems with the amount of compaction in one section versus another—again to find out how much compaction affects the roadway."

Because drainage systems for removing water from the roadway can be fairly expensive to build, Newcomb and other researchers are also trying to ascertain exactly how much good they do. By incorporating drainage systems in some sections of the test system and not in others, they will be able to compare the performance of the roadways to see if the drainage devices are in fact worth the extra dollar.





The Smith Avenue High Bridge across the Mississippi River in downtown St. Paul was demolished in 1985. The entire project cost for replacement? $19.8 million. Photos courtesy Mn/DOT.

The primary constraint to the project, it seems, is finding enough money and people to analyze the vast quantities of data the project will generate. "The amount of data we can gather is mind boggling," says Benke. "We're talking about giga-bytes of data that's available. And, we have to be very selective as to what data we save and how we store it if it's going to be useful." To do that, Benke and officials at Mn/DOT are working with Computer Science and Civil and Mineral Engineering professors to design a workable database.

Eventually, the computer at the test facility will not only monitor the test road system, but will presort, package, and label the incoming data. "We're trying to organize the database so that researchers throughout the country and world will have access to the information for further research," says Benke.

Given the availability of this information, it's clear that what has started as a microscopic view of roadways through the Minnesota Road Research Project, will invariably pave the way to better road designs throughout the nation and perhaps the world.

Traffic: stuck in the jam

You're cruising down the freeway at 55 mph, with just enough time to make your appointment on the other side of town. And then it happens. Someone hits their brakes half a mile up the road, triggering a domino reaction of red lights down the lane. You slam on your brakes in turn. Now what? Is there an accident up ahead or is it just a short bottleneck? How long will you be stuck? Are there alternative routes?

If you're like most Americans, you won't have the answers to any of these questions and you'll remain stranded in the standstill for the duration. In fact, Americans currently spend about two billion hours (228,000 years) annually in traffic jams. But that's not the worst of it. The number of standstill hours is expected to increase 400-500 percent by the year 2005 if nothing is done to improve traffic problems.

As people and cars idle the time away in standstills, the cost to the U.S. and American companies is billions of dollars in lost productivity. On the environmental side, roughly three billion gallons of gasoline were exhausted on American freeways for naught in 1984 alone, all while the fuel's residue of hydrocarbons generously polluted the atmosphere. And thé list of traffic problem outcomes goes on —everything from companies in gridlocked cities having trouble luring employees to their offices, to ever increasing costs associated with moving people and goods throughout this vast American domain.

Mn/DOT, in conjunction with the Center for Transportation Studies at the University of Minnesota, however, has one of the best road maps in the nation when it comes to planning solutions to the traffic dilemma. Posed under the label of Intelligent Vehicles and Highway Systems, the new system will connect and monitor nearly 300 miles of freeways and major arterials in the Twin Cities as early as 1995. The centerpiece of the new system will be a new high-tech invention recently patented by the University of Minnesota named AUTOSCOPE (TM)—a wide-area vehicle detection and automatic surveillance device —as well as software that capitalizes on AUTOSCOPE's (TM) unique features.

Right now, data on traffic volumes and speed is collected through loops located approximately every half mile in the freeway pavement. That information, along with images from cameras overlooking the freeway, is transmitted to Mn/DOT's Traffic Management Center—the electronic nerve center for the traffic management system. There, Mn/DOT personnel view the information on numerous monitors and make appropriate changes to ramp metering and changeable message signing based on traffic levels. They also notify the State Patrol or highway maintenance crews of accidents or breakdowns.

"The problem with this technology is that to place or repair the loops, you have to stop traffic and cut up the pavement," says Richard A. Stehr, director of Mn/DOT's Office of Traffic Management. "Invariably, the seals around the loops leak, and water gets in. Eventually, it freezes, thaws, and breaks the wires as well as the pavement. At any one point in time, somewhere between three and 10 percent are malfunctioning, and we aren't able to collect the necessary information." What's more, it's impossible to obtain information where there aren't any loops, such as on the shoulder of the road, according to Stehr.

AUTOSCOPE (TM) will change all that. Using input from video cameras overlooking the roadway, AUTOSCOPE (TM) simultaneously detects traffic in real time at multiple points on the roadway. Instead of placing loops physically in the pavement, you simply specify where you want to place your "detection lines" on the systems monitor—a mouse-drawn line—and a signal compatible to loops is generated each time a vehicle crosses the line. Because you can change the placement of your detectors and view other parts of the freeway (such as on the shoulders or ramps), AUTOSCOPE (TM) offers much more flexibility than the current loop detectors, as well as the ability to cover more ground. Best of all, it's substantially less expensive.

Tremendous pressure builds when storm runoff plunges toward the main sewer interceptors, sometimes literally blowing the cover off dropshafts.

The advantages of AUTOSCOPE (TM) do not stop there, however. Computer software allows traffic management operators to be automatically alerted in the case of accidents or breakdowns so they can take appropriate action. At the same time, it automatically processes information and generates data identifying congestion levels and then appropriately adjusts signage and ramp metering as necessary.

Ramp metering—to some people's chagrin—is an important component of traffic management. And even though today's average American motorist will spend an estimated six months of his or her lifetime waiting for red lights to turn green according to a study by Priority Management Pittsburgh, more stop lights—not fewer—are proposed for the entrance ramps of our freeways. The reason is, they work to reduce trip time.

"A lot of people think ramp metering is intended to keep traffic off the freeway, but it really helps carry more traffic safely at higher speeds," says Glen C. Carlson, manager of the Mn/DOT Traffic Management Center. "Without freeway metering, traffic would grind to a standstill. From 1974 to June 1988, we increased the speed from 34 miles per hour to 46 miles per hour, or 35 percent, during peak periods, and at the same time increased the volume by about 15 percent. Accidents decreased from 421 to 308 per year, or 27 percent during that time, and the accident rate (which takes into account increased volumes in traffic of four percent per year) decreased from 3.40 to 2.11, or 38 percent."

A typical freeway can generally carry up to about 1,800 vehicles per hour, per lane at speeds of about 35 to 40 mph. "More than that, and it becomes unstable," says Stehr. "As soon as somebody hits their brakes, the speed and volume drop, and you end up in stop-and-go traffic. What we found with ramp metering is that we can increase freeway volume to about 2,400 vehicles per hour, per lane before it starts breaking down."

How does ramp metering work to reduce traffic problems? First, it creates a uniform density in traffic entering the freeway and eliminates the shock waves and heavy surges of traffic that would otherwise come on the ramp all at once. Let's face it. Minnesotans may be generous, but they're not that generous. "People are willing to let one or two cars merge in front of them," says Stehr, "but not six or seven. So you end up with a face-off at the end of the ramp, and pretty soon, the brake lights go on, and the traffic volume goes down to only 1,200 or 1,300 vehicles per hour, per lane."

Second, it discourages the short-distance freeway driver. "A lot of people get on one ramp and off at the next, just because it's faster and they miss a few street lights," says Stehr. "Now they have to wait at the ramp, and it's easier for them to take the local street. From our standpoint, freeways are made for longer trips. When you have high-speed lanes and there's a lot of on-and-off traffic weaving down the freeway, it reduces its efficiency."

With a sophisticated traffic management system almost in place, the race is on to find ways to communicate traffic information to the driver. "Right now, our traveler information systems are fairly elementary," says Stehr. "If you're just getting on the ramp, and you hear there's an accident over the radio, it's too late—you're already stuck." Not only does the driver have to take the initiative to turn the radio to the right station, the information might only apply to a small piece of roadway. The ideal system, all agree, would inform the motorist *before* he or she leaves home or the parking lot.

Although Mn/DOT hopes to start broadcasting traffic information on cable television in February to address this problem, research is already underway for bigger and better traveler information systems. In the future, it could be that a "guidance system" located on the dashboard of your car will monitor traffic levels and tell you the best way to reach your destination, or that your personal computer will be equipped with up-to-date information on traffic levels that you access before leaving your office or residence.

When it comes to traffic management, however, the high-tech innovations don't stop there. Imagine you've just merged onto the freeway. You push a button in your car, and automated controls take over the driving for you as you sit back and read the newspaper. The car's collision avoidance systems regulates your speed according to that of the car at the head of the pack and knows when to brake.

Although it sounds pretty cushy, the point is, Advanced Vehicle Control Systems will have a tremendous impact on reducing traffic levels. "If you're traveling at 55 to 65 mph, you need to have about 300 feet in between vehicles for safety reasons," says Stehr. "With automated control, on the other hand, you could reduce that to one-foot intervals and pack a lot of cars into that space, perhaps tripling the capacity of the freeway."

Whatever the future holds for addressing traffic management problems, it's clear that the research and technology developed at the Institute of Technology will help keep Americans pointed in the right direction and out of the jam.

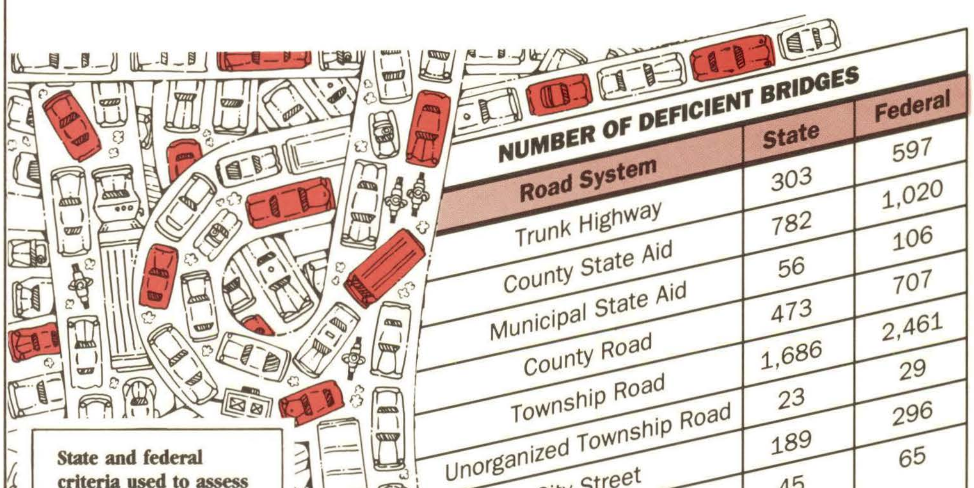
Bridges: spanning the gap

In April 1987, the bridge over Schoharie Creek collapsed on the New York State Thruway, 40 miles northwest of Albany. Ten people plunged to their deaths into the turbulent floodwaters of the creek below. Although bridge replacement and repair may not be our most important need when it comes to addressing the nation's infrastructure problems, according to Braun, it is by far our most dramatic. "If a road disintegrates, somebody puts a patch on it and you just keep using it," he says. "But when a bridge falls down, everybody knows about it, and you have a big problem; it's like an airplane crashing."

The problems eating away at our bridge structures span the spectrum from corrosion and deformation to costly environmental hazards such as chipping flakes of lead-based paint. Perhaps most prevalent are the problems caused by the more natural phenomena of simple old age.

"The way I see it, we're at the tip of an iceberg," says Donald J. Flemming, state bridge engineer for Mn/DOT. Many of our bridges were built following World War II as we moved toward construction of the interstate system, and they are coming to the end of their useful life. Over the next 20 years, the number of critically deficient bridges is going to double. If we don't take care of the problems today, we'll have an insurmountable problem down the road."

To compound the problem, bridges that are still in good repair may need to be replaced because of their design limitations. "There are two major problems as far as bridge structures are concerned," says Catherine French, associate professor of Civil and Mineral Engineering. "One is the deterioration of the structures, and the second is the ever increasing size and weight of the vehicles we put on the roads. So even bridges that are in good condition have to be evaluated to see if they can handle the heavier vehicle load."



NUMBER OF DEFICIENT BRIDGES

Road System	State	Federal
Trunk Highway	303	597
County State Aid	782	1,020
Municipal State Aid	56	106
County Road	473	707
Township Road	1,686	2,461
Unorganized Township Road	23	29
City Street	189	296
Miscellaneous (e.g., National & State Forest Roads, Indian Service Roads, etc.)	45	65
TOTALS	3,557	5,281

State and federal criteria used to assess bridge deficiencies differ, but either way, thousands of Minnesota bridges are in need of repair or replacement. Source: Mn/DOT.

Part of the dilemma in addressing these needs—immediate or otherwise—is, of course, money. Bridges aren't cheap. Of the 573,928 bridges that span a distance of 20 feet or longer in the United States, more than 42 percent are in need of rehabilitation or replacement according to a 1988 federal survey. The cost? More than $50 billion. And that's not to mention the multitude of other associated costs, such as revamping the roadways leading up to the bridge (which can average as much as 50 percent of the replacement cost of the bridge itself) or the cost to the motorist and nation in terms of lost time, fuel, and productivity as a result of detours.

When it comes to numbers, Flemming paints a pretty bleak picture of Minnesota bridges, even though the state fares far better than most of its neighbors. While the state's bridge replacement needs run about 27 percent according to a November 1988 article in *Better Roads*, other states like South Dakota and North Dakota run as high as 48 percent and 54 percent, respectively. Flemming projects that of the 19,492 bridges in Minnesota, another 4,276 will become critically deficient over the next 20 years, for an estimated cost of about $1.7 billion, or $80 to $90 million per year.

"We're not hitting that mark by a long ways right now," says Flemming, "And, nothing has been done to increase the budget. In fact, it's been going downhill." Over the last 12 to 13 years, Mn/DOT has operated with an average annual bridge budget of roughly $54 million.

It's clear that if there's not enough money to buy bridges, something needs to be done to buy time. And French and her colleagues—Ted Galambos and Roberto Leon—hope to accomplish just that with one of their research projects that will better assess which bridges are in need of immediate repair or replacement.

Their research has shown that steel beam and girder-type bridges have considerable reserve strength because of inelastic force redistribution both along the beams and across the width of the bridge. According to French, most current bridge rating systems are fairly conservative and do not take this into account. Consequently, a large number of bridges are rated deficient when in fact they can still carry the necessary vehicle loads by allowing some inelastic deformation. "Even if a redundent bridge has some inelastic deformation, it's not going to fail," says French. "In many cases, it will still maintain and carry appropriate vehicle loads very well because the bridge will redistribute the loads."

The rating method developed by French, Galambos, and Leon, called Residual Damage Analysis, determines how much load the structure can carry without exceeding the deflection limit specified by rating engineers. The result is a rating method that gives transportation departments more realistic information on which to make decisions about bridge replacement and more time to cope with the growing problem.

When it comes to bridge planning, however, sometimes other important data necessary for making optimum decisions can be a little fuzzy. The anticipated life of a bridge, for example, is anywhere from 20-60 years, and a number of bridges manage to outlive the upper end of that age range without difficulty. Such was the case with the Lake Street Bridge in Minneapolis, for example, which only succumbed after 101 long years of carrying its heavy loads and stress. So, how does one prepare for the future when factors, such as a bridge's potential life span, are unknown?

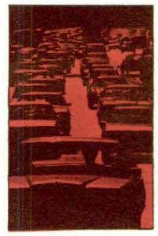
French and her colleagues were given a golden opportunity to add to that field of knowledge when road realignment necessitated the replacement of a bridge on Boone Avenue and I-694 in Minneapolis. In that project, they subjected the 20-year-old bridge girders to about three million cycles of fatigue tests to determine their remaining useful life and also evaluated such aspects as corrosion caused by deicing salt. At the same time, they developed methods for repairing reinforcement damaged by overheight vehicles striking the bridge, and then subjected those repairs to fatigue tests to evaluate their methods.

"Many prestressed bridge girders around the country are on the order of 20 to 30 years of age and are nearing the end of their anticipated service life," says French. "It's important to evaluate the remaining useful life of these girders in order to plan for replacement needs and to gauge the life of rehabilitated bridge decks."

As most Minnesotans know—usually in the spring, when they travel from one pothole in the road to the next—another factor that affects the life of their transportation system is the deicing salts so generously applied during the numerous frozen months of the year. Bridges are not exempt from the harmful effects of deicing salts and moisture that, as with roads, permeate the concrete at spring's first thaw.

To solve the problem, French and her colleagues are experimenting with the use of reinforcement coatings and silica fume in the concrete mix to make it less permeable. "Silica fume used to be a waste product in the chimneys of companies that built silicon chips," says French. "They used to have to tote it away as a waste product. Now they sell it for a lot of money because it not only makes concrete very impermeable, it also increases the strength of what used to be considered high-strength concrete by about four times."

Now, if you can increase the strength of concrete, you can also increase the load on the structure, as well as possibly achieve longer, lighter, and wider girder spacings, according to French. This is the next topic she and her colleagues are researching for new bridge structure design. They're also investigating how quickly concrete will achieve acceptable strengths in the casting process in the hope that it will reduce the turnaround time for casting girders at the plant.



Sewers: troubled waters run deep

We're all familiar with the story: sutures, hypodermic needles, and vials of blood wash up on the shores of beaches from Staten Island to eastern Long Island, shutting down resorts as possible health hazards. While scuba divers talk of swimming through clouds of toilet paper in the San Francisco Bay, numerous other beaches throughout the nation are marked off-limits due to bacterial contamination caused by sewage.

With waste turning up in all the wrong places, Americans have been forced to focus on the growing problem they all thought was forever buried deep beneath their cities. The culprit it appears—at least in part—is not entirely industry this time. It's our nation's 800,000-mile sewer system, which is not only suffering from old age, but unable to cope with the needs of our burgeoning urban populations.

Some sewers are so old that their linings have deteriorated within the pipes, drastically reducing the capacity of the system to handle the flow. In other cases, cities continue to rely on dilapidated systems made of brick and even wood to safely cart the sewage away. Unfortunately, these now cracking and leaky structures have turned what should be a sewage conveyance system into something that resembles more of an irrigation system. That which they are irrigating—or rather contaminating—is our groundwater. Alternatively, goundwater seeps into the sewer system through the numerous cracks, fissures, and leaky pipe joints, increasing the water flow to a point where treatment plants have difficulty coping with the volume—or added expense.

And sewer systems, like most of our other infrastructures, are not cheap to repair, replace, or expand. In many cases, they tunnel their way in a tree-like fashion at depths of 100-300 feet below our cities. Entry points to access the system are generally few and far between, which means repair work often involves miles of underground tracking to appropriately evaluate the problems.

"We're talking about tunnels 15 to 20 feet in diameter in some cases—which is almost as big as a traffic tunnel—placed at depths of 200 to 300 feet below the ground," says Heinz Stefan, professor of Civil and Mineral Engineering. "In a recent sewer expansion project in Minneapolis, many miles of a new main interceptor were excavated underground using a large machine to bore out a circular cross section in the sandstone underneath the city. So, these are indeed very significant projects."

In addition to the magnitude of these projects, our imposition of higher water-quality standards has also upped the ante when it comes to costs. Although the Environmental Protection Agency has done much to improve the nation's waters by imposing strict standards, for example, maintaining those standards is projected to cost as much as $400 billion more by the year 2000.

Even if American cities had the money, it would nonetheless be difficult for many to comply with these standards. New York City, for example, still releases eight million tons of sludge annually directly into the Atlantic according to some reports, because its sewer system cannot handle the 1.7 billion gallons of sewage the city produces every day. What's more, the city's rickety sewer system unloads millions of gallons of raw sewage at a time directly into the harbor during periods of heavy rainfall.

New Yorkers are not alone—at least when it comes to problems associated with their sewers and heavy rainfall. Most city sewer systems started off as sanitary sewers that carried off waste from man-made facilities. As the cities became more urbanized and storm water had to be removed, storm sewers were simply combined with the sanitary sewers.

"The problem with combined sewers is that during a heavy rain, you have an enormously large volume of water over a very short period of time that the sewer system cannot handle," says Charles C. S. Song, professor of Civil and Mineral Engineering. "When the water flow exceeds the sewer's capacity, it becomes pressurized to the point where the water may even erupt like a geyser through a manhole. It can be quite damaging to the sewer and the surrounding area. When water burst through a manhole cover in downtown Chicago a few years ago, it washed away a few cars."

In addition to physical damage, combined sewer systems also result in a pollution problem. "It was discovered some 15 years ago that storm water coming off streets can be as bad as or worse than sewage because it collects large amounts of pollutants, such as gas, oil, antifreeze, and fertilizer," says Stefan. As a result, cities collect it now and treat it to the extent possible before discharging it." Unfortunately, treatment plants can only handle a small amount of sewage/storm water at a time. During heavy rains, water flow not only surpasses the sewer's capacity, it surpasses that of the treatment plant as well. The result, like in New York, is the release of untreated sewage directly into the rivers or oceans.

"It's not economical or feasible to build a large treatment plant to handle the maximum flow rate," says Song. "The alternative is to separate your storm and sanitary sewer system, which can be quite costly, or find ways to store that excess water and then pump it out during dry periods."

Song, Stefan, and their colleagues at the St. Anthony Falls Hydraulics Laboratory have been helping cities across the nation address these flow and storage problems in sanitary and storm sewers by studying and recommending design and operational modifications that will work with their particular systems. In Chicago, for example, these researchers have helped design a system that not only carries the large volumes of sewage and storm water safely from one point to another, but that can be used for storage purposes as well during heavy-flow periods. Part of their work has involved the design of drop structures to connect the large underground tunnels that convey and store the water with the collectors beneath the streets.

"Dropshafts are an important part of the design problem," says Stefan, "because storm water runoff will drop into main interceptors 100 to 300 feet below street level, releasing large amounts of energy. If the structure doesn't have a way to dissipate that energy safely, then the flow impinging on the rock will create large cavities underneath the urban area with potential for collapse of buildings and other disasters. So, it's a very threatening situation."

To cushion the water's impact on the bottom of the dropshaft, an air/water mixture is created by induced entrainment. "The problem is, what do you do with that air at the bottom of a dropshaft?" asks Stefan. "You don't want to leave it because it will reduce the sewer tunnel's conveyance, and you don't want to release it above ground because of its foul smell." To solve the problem, an air separation chamber was experimentally developed at St. Anthony Falls Hydraulics Laboratory that allows the same air to recirculate over and over again throughout the system.

Although Stefan happily admits that their dropshaft design has become somewhat of a generic device being implemented in cities across the nation, it's clear that each city has its own specific needs and that each structure location is unique.

When officials from Phoenix wanted to design three drop structures to convey freeway storm water from interceptor lines to underground conveyance tunnels, for example, it was evident that dropshaft designs developed for other locations with higher drops could not be used. Models used to determine the optimum design indicated that to provide a structure large enough to effectively dissipate energy and provide air removal, the sump beneath the vertical shaft needed to be excavated below the invert elevation of the exit tunnel. A sloping floor in the sump was then used to guide the flow back up to the tunnel elevation.

The City of Rochester, New York, posed yet other design challenges—particularly given its size. The project, which involved developing a combined sewer overflow and abatement plan to handle sanitary sewage and storm water, consisted of 40 dropshafts along a 26-mile-long tunnel with drop heights varying from about 40 feet to 150 feet handling discharges from about 100 cfs to 900 cfs.

Because of the relatively low drops at many locations and the thin rock layers underneath the ground surface, a hydraulically acceptable sump with a lower height was developed at the St. Anthony Falls Hydraulics Laboratory. At several locations along the tunnel, the researchers proposed constructing surge shafts to attenuate surge pressures in the system and to combine them with conventional dropshafts. These combined surge and dropshaft structures will have dual functions of conveying water from the ground surface to the underground tunnels and relieving surge pressures in the system.

"Dropshafts, storm water tunnels, and sewer pipes are things a lot of people never think about because they're underground," says Stefan. "They just assume that water running off a street is taken care of and that somehow sewage magically—and safely—disappears."

But given the focus on environmental issues and the protection of our water resources, it's clear that this part of our nation's crumbling infrastructure will not continue to be out of sight or easily out of mind for long.

Outlook: strengthening our fragile foundations

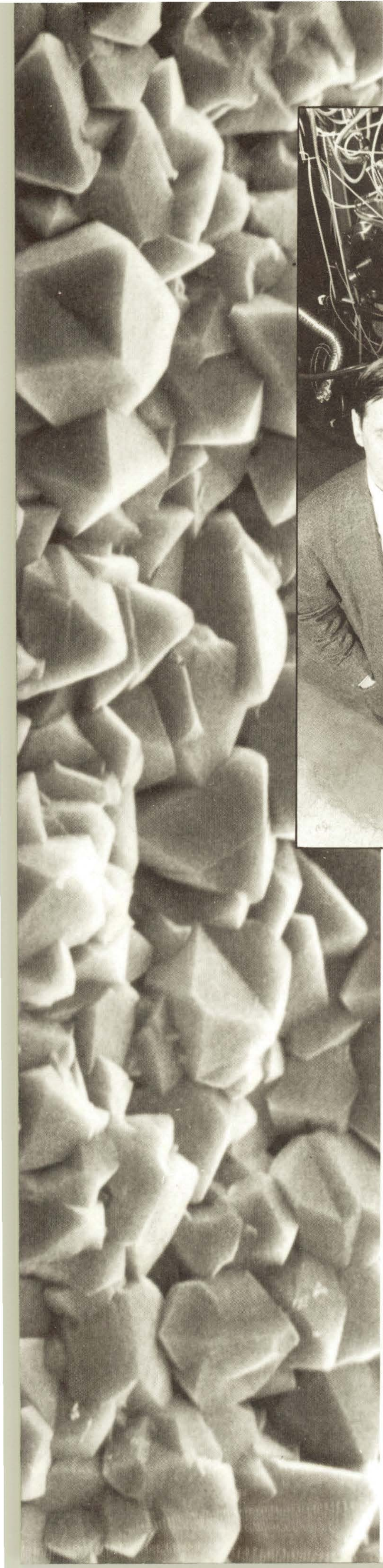
Anyone who has ever played Monopoly knows that it's a sure way to lose the game: buy up as much property as you can and forget about stashing enough cash away to cover your investments with hotels. In a

continued on page 21

Precious science

Three IT plasma scientists turn ordinary methane gas into diamond!

By Miriam K. Feldman



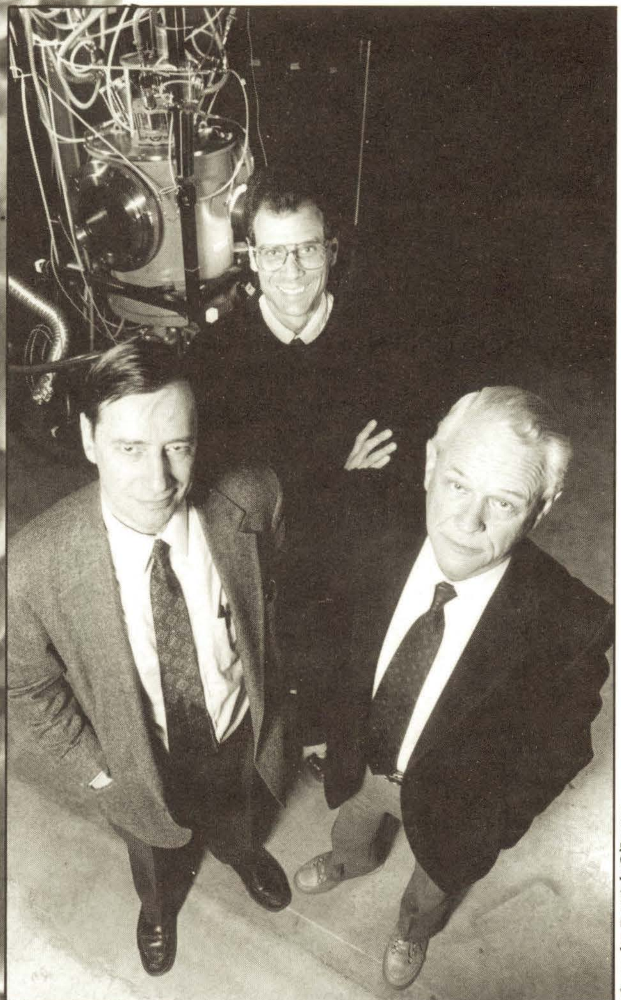


Photo by Patrick O'Leary

Left: Thousands of diamond crystals—each less than 50 microns across—comprise the diamond film IT's plasma scientists have been able to synthesize. Inset: (left to right) Mechanical engineering faculty members Joachim Heberlein, Steven Girshick, Emil Pfender, and their diamond synthesis chamber.

Diamond, the hardest and perhaps most coveted naturally occurring substance known to man, formed millions of years ago when the intense heat and pressure found deep within the Earth crystallized pieces of pure carbon. Uncountable centuries passed before geological transformations, such as volcanic activity and erosion, slowly pushed some of the precious gems near or onto the Earth's surface, and even more time passed before man had the wherewithal to mine the brilliant stone where it remained locked deeper within its original rock matrix. Its aesthetic value to people over the centuries and its more recent practical application to industry have caused many a business person, entrepreneur, and miner alike to labor their lives away in pursuit of the sparkling gem.

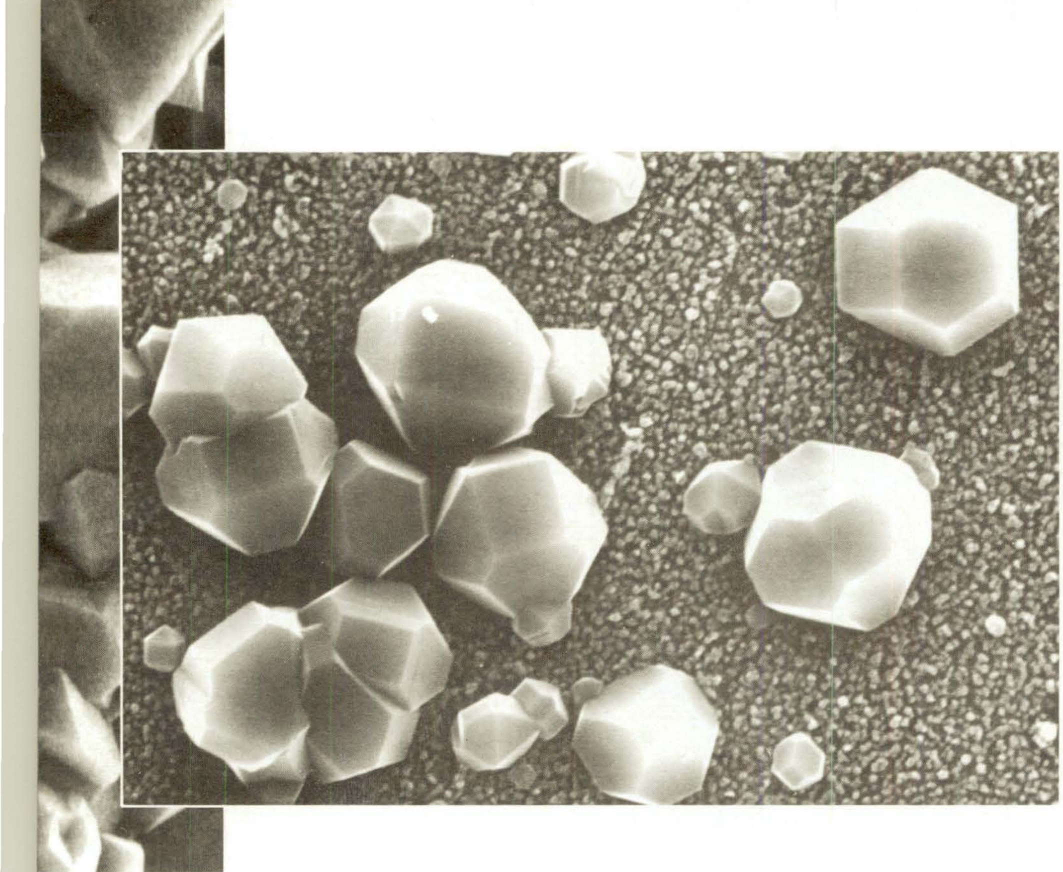
But now, University of Minnesota professor Emil Pfender and associate professor Joachim Heberlein are helping change this several-million-year process of creating and cultivating diamonds into one that can be accomplished in a matter of minutes. In fact, they have found a way to create diamonds faster than almost any other known process—producing diamond crystals within 10 minutes and diamond film within five hours. At this rate, they are out among the front runners in the area of diamond synthesis.

Ironically, given their success, these Minnesota engineers have been synthesizing diamonds for only about six months and call themselves "latecomers" to this field that is teetering on the brink of commercial application. One other person in their department, assistant professor Steven Girshick, has been synthesizing diamonds, using a slightly different process, for about a year.

Perhaps more ironic is the fact that both Pfender and Heberlein are plasma scientists—not diamond synthesis researchers. In fact, Heberlein and Pfender, both German, came to Minnesota via the Institute for Plasma Research at the University of Stuttgart. Pfender has been at Minnesota for 26 years, and Heberlein arrived a year ago, after first working with plasmas at Westinghouse. Nonetheless, it was their sophisticated knowledge of plasmas that opened the door to the field of diamonds.

Plasma, Pfender explains, is a very hot, partially ionized, electrically charged gas. It is emitted from a torch in what looks like a combustion flame, but at a temperature of more than 10,000 degrees Celsius. When this super-heated gas comes into contact with materials, it transforms them. Plasma gases have been used for a number of years to spray ceramic coatings on everything from turbine blades to space vehicle nose cones. More recently, they have been used in the synthesis of diamonds.

In Pfender's lab, plasma gases are emitted from a special device that Pfender designed and patented in 1989 under the name Multiple Arc Plasma Device with Continuous Gas Jet. This device emits plasma from three nozzle-like torches that are positioned downward to improve



uniform heat control. A fourth nozzle, positioned in the center of these three torches, emits material transformed by the plasma gas. In the case of diamond, methane and hydrogen is emitted from one torch while plasma shoots out of the other three. All four nozzles are aimed at a substrate—or plate—that holds the material to be coated with the diamond film.

The "recipe" for diamonds seems simple: To make a diamond, take methane (CH4), which is one carbon and four hydrogen atoms, and heat the methane with the plasma until it dissociates or breaks up. The hydrogen atoms escape into the air or form other compounds. The remaining carbon is transformed under the intense heat into diamond crystals that are then pressed together to make a film. In the most simplistic sense, this coating may be compared to paint, brushed onto a surface, and left to dry.

Although this process has numerous applications, it's not likely to put De Beers out of business any time soon. The resulting diamonds are so small that it takes about 62 billion to make one carat. Even magnified 25 times, they look like specks. The biggest diamond Pfender has synthesized is about 50 microns—a micron being one-thousandth of a millimeter.

As small as they are, these diamond crystals have piqued the curiosity of scientists everywhere and will transform countless industrial processes. International conferences devoted exclusively to diamond film met for the first time last year, and this year, the second in a series of conferences will be held. "Over the last few years, this whole field has been set up as an interdisciplinary activity on its own," says Girshick.

In terms of hot topics among materials scientists these days, diamond synthesis has only one rival—the high-temperature superconductor, Girshick says. So far, synthetic diamond is leading the race toward commercialization, however. Once it crosses the finish line into the commercial arena, it will make some industrial processes obsolete and aid in further developments.

The reason for all the excitement is that diamond, as Heberlein points out, "is such a wonderful material." Because it is the hardest known material and has the largest index of refraction, it interacts well with light. It also has excellent thermoconductivity properties, which means it conducts heat very well, and is a very good insulator because it does not conduct electricity. Finally, diamond produces little friction and, consequently, little heat when interacting with another surface.

Each of these qualities makes diamond the material of choice in various industrial processes. For example, its hardness makes it ideal for cutting. A material such as aluminum tends to melt when cut on a lathe, but not when cut with diamond.

Diamonds are not changed by nuclear radiation, so they are useful in nuclear power plants. And they are excellent "optical windows." Normal glass or quartz cuts off light, but diamond allows the entire spectrum—from ultraviolet to infrared—to penetrate, making it useful in laser technology.

As a thermoconductor, diamond can be used to cool microcircuitry by drawing heat away from elements that must stay cool. "The more complex microcircuits become, the bigger issue this will be," Heberlein says. At the same time, diamond's low friction level makes it useful in bearings, turbines, and car engines because where there is friction, there is energy loss.

Girshick has been collaborating with General Motors to apply diamond coating to engine components and brake parts. Although diamond film is not yet commercially available in the automotive industry, a number of companies have very aggressive, strongly supported research programs, including General Electric (GE) and Texas Instruments, according to Girshick. GE is building facilities for applying diamond films, and a number of start-up companies (most notably in California) are taking the lead with this new technology, he says. The Department of Defense also has been extremely interested in diamond films and has funded numerous research projects in this field.

But diamond synthesis is not new. It dates back to 1955 when GE simulated temperature and pressure conditions 240 miles deep within the Earth. The amount of pressure applied equaled about 50,000 times that of our atmosphere, which would be equivalent to placing the weight of something like the Empire State Building on a small piece of carbon, says Heberlein. But the limitation of the GE process, which generates $1 billion a year in sales for the company today, is that it creates single diamonds—not a diamond film.

By the mid-1970s, the Russians had discovered a way to synthesize diamonds at one atmosphere (the earth's air pressure) and at reduced pressure (one-hundredth of one atmosphere or below). Soon after, the Japanese got into the act and were the first to reach success with the low-pressure process, according to Heberlein. Only in the mid-1980s did Americans wake up and become involved in this field, he says.

Both Heberlein and Pfender are quick to put their work into perspective and acknowledge that many people are synthesizing diamond coatings with plasma gases. But not many are synthesizing the diamonds at one atmosphere. And, at one atmosphere, diamonds are created more quickly than at reduced pressure.

Now that they know their process works, Pfender and Heberlein plan to improve the rate at which they synthesize diamond particles. They also want to be able to create diamonds with particular qualities to meet specific needs. "You want to understand the process well enough so you can get exact results for specific applications," Heberlein says.

Despite all the interest in diamond synthesis, it will be anywhere from two to five years before diamond films are ready for commercial use. But, ultimately, the average person will be well aware of diamond coatings, Girshick says. For one thing, products using diamond film will be heavily advertised because of its many commercial uses, he says.

Girshick predicts that everything from razor blades to scalpels will be diamond coated. And good-bye Teflon. Pans will be diamond coated for better heat distribution. Biomedical devices, like hip joints, will be coated with friction-resistant diamond. Windshields and eyeglasses will be coated with scratch-resistant diamond. And diamond will be used in all sorts of electronic equipment.

Even though it took us millions of years to get from the creation of the world's first diamonds to its synthesized version, it's evident that it won't be long before the sparkling substance becomes part of our everyday household items. And if the history of technological advancement tells us anything, in another 15 years, we'll probably wonder what we ever did without them. I

Miriam K. Feldman is a Minneapolis-based freelance writer.

Left: Individual synthesized diamond crystals. Above: A cross-section of a diamond film synthesized at IT.

CALENDAR

April

25 Sweatt Lecture Series; Center for the Development of Technological Leadership; Dr. Jay Forrester; Germeshausen Professor, Emeritus; Senior Lecturer; Massachusetts Institute of Technology; Sloan School of Management; "Designing Social and Managerial Systems"

May

6-10 IT Week. Contact IT Student Affairs, 612/624-8509.

9 Sweatt Lecture Series; Dr. Simon Ramo; Co-founder and Director Emeritus; TRW Inc.; Chairman, Aetna, Jacobs and Ramo; Technology Ventures; "The Coming More Technologcial Society"

9 Science and Technology Day/IT Alumni Society Annual Meeting. Banquet dinner with guest speaker Kerry Kelts, Professor and Director of IT Limnological Research Center. Topic—Global Change. Contact Cheryl Jones, 612/624-2323.

31 IT Commencement. Northrop Auditorium, 7:00 p.m. Presentation of Outstanding Achievement Awards.

June

14-15 Chemcial Engineering and Materials Science All-Alumni Reunion. Contact Ms. Terry Jokapii, 612/635-1313.

October

10-12 IT 1941 Class Reunions (held in conjunction with Homecoming). Contact Linda Goertzen, 612/624-2006.

Photo by Patrick O'Leary

Larry Jacobson

Travelin' man

When the telephone rang, Larry Jacobson was quick to answer. Throughout his career, he had grown used to the numerous requests asking him to make house calls to help sickly patients. But this time, the caller told him the patients—a herd of pigs—were doing just fine. It was the farmer who wasn't doing so well.

As associate professor of agricultural engineering for the University's Agricultural Extension Service, Jacobson is the man on whom county extension agents, veterinarians, and farmers rely when they have questions about his specialty—livestock housing, particularly for swine. He trouble-shoots, consults, and teaches on 50 to 60 Minnesota farms each year, offering expertise on layout, energy efficiency, air-quality, waste handling, and many other aspects of housing for animals.

As might be expected, proper livestock housing improves animals' health and welfare, but it often has a dramatic effect on the farmer, too. When Jacoson learned that the farmer mentioned above suffered from severe headaches and other health problems, for example, he suggested air quality tests for the farmer's barn. The tests revealed abnormally high levels of ammonia and carbon dioxide. When the farmer implemented Jacobson's suggested improvements to the ventilation system, his health problems ended. Such practical applications of engineering principles are typical of Jacobson's work. He calls it "teaching in the real world."

Jacobson spends at least a third of his time traversing the state to make his house calls. And he is constantly seeking new ways to "multiply" himself to assist everyone who needs his advice. He conducts seminars for veterinarians, vocational teachers, and extension agents who, in turn, spread his knowledge. For his efforts, Jacobson received the 1990 Engineering Achievement Young Extension Worker Award from the American Society of Agricultural Engineers in December.

Jacobson was the catalyst in the formation of the Minnkota Agri-Builders and Equipment Association, a non-profit industry association that brings experts together from the University of Minnesota, North and South Dakota State Universities, and the farm building and equipment industries of those states. Through the association these often adversarial groups work together to give farmers accurate information for their animal housing needs.

While he devotes the majority of his time to extension work, Jacobson invests the remainder in research—a combination which he feels fosters an excellent exchange of information between the laboratory and the field. He also coordinates multidisciplinary efforts with the public health faculty and the School of Veterinary Medicine to study the effects of livestock barns on human health.

Although Jacobson grew up on a dairy farm in Pelican Rapids, Minnesota, his academic interests lay more with math and science than with the family farm—that is, until he realized the extent to which his background in civil and mechanical engineering could be applied to agriculture. Jacobson feels that his farm background gives him added ease in communicating and understanding the needs of Minnesota farmers.

"It's a real warm, fuzzy feeling for me to trouble-shoot on farms, identify problems, and make recommendations," he says. "Farmers ask me, 'Is there any charge for this?' I say, 'No, it's your tax dollars at work.' It's very gratifying to get the University's information out to the people." I

By Terri Peterson Smith

Astronomy

Regents' Professor ***Edward P. Ney*** retired fall quarter and was honored at a dinner at the Campus Club in February.

Chemical Engineering

Professor ***John Weaver*** was elected to the Board of Directors of the American Vacuum Society and was named principal editor of the *Journal of Materials Research*. ***Henry White*** was promoted to associate professor. Two new faculty members joined the department this fall: ***Lorraine Francis,*** assistant professor, and ***Michael Ward,*** associate professor. Francis completed her doctorate in ceramic engineering at the University of Illinois. Ward, who has been working as a research scientist, received his doctorate from Princeton University.

Chemistry

Professor ***Peter W. Carr*** received the Benedetti-Pichler Award from the American Microchemical Society on November 15, 1990 for his contributions to microanalysis. Professor ***Edward Leete*** received the Pergamon Phytochemistry Medal and a cash prize of $5,000 in December from Pergamon Press, London, for his distinguished contributions to phytochemistry during the last 40 years. Associate professor ***Hung-wen Liu*** received the Research Career Development Award from the National Institutes of Health in July. A symposium titled "The Thermodynamic Basis of Protein Structure & Function" was held in Kansas City on October 4-6, 1990, in honor of professor ***Rufus Lumry.*** The symposium coincided with Lumry's 70th birthday. Assistant professor ***Jeffrey T. Roberts*** received the New Faculty Award for 1990 from the Camille and Henry Dreyfus Foundation. The program is designed to provide external support for new faculty members who have exhibited promise through their graduate and postdoctoral accomplishments. Roberts, who specializes in physical chemistry, joined the faculty in August. Assistant professor ***Scott D. Rychnovsky*** received the Teacher-Scholar Award for 1990 from the Camille and Henry Dreyfus Foundation. The award is given to faculty members in the early stages of their academic careers to assist them in accomplishing their high-level work. ***William Tolman*** joined the chemistry department as an assistant professor in August. Tolman, who had been a post-doctoral associate at the Massachusetts Institute of Technology, specializes in bioinorganic and organometallic chemistry.

Civil and Mineral Engineering
Ray Sterling, director of the Underground Space Center and Shimizu Professor of Civil and Mineral Engineering, was a visiting researcher during late January in the Underground Space Development Program of the National Research Institute for Pollution and Resources in Tsukuba, Japan.

Computer Science
Professor ***Marvin L. Stein*** resigned effective fall quarter 1990 as director of graduate studies. Stein, who will continue his work as a member of the faculty, chaired the committee that established the computer science graduate program and served as the program's director for three years. At a reception on November 12, IT Dean Ettore Infante presented Stein with a commemorative plaque honoring him for his "dedication and contributions to the development of high-quality graduate education in computer science." Associate professor ***Maria Gini*** is the new director of graduate studies.

Electrical Engineering
F. N. Bailey was promoted to the rank of professor. Assistant professor ***Stephen Chou*** received a Packard Fellowship from the David and Lucille Packard Foundation of Los Altos, Calif., in November. Chou was one of only three engineers nationwide to receive a Packard Fellowship this year. The award is for $100,000 per year for five years. ***M. Kaveh***, professor and department head, presented the graduate seminar at the Department of Electrical and Computer Engineering at Carnegie Mellon University in November. Assistant professor ***Keshab K. Parhi*** received the Institute of Electrical and Electronics Engineers' (IEEE) Browder Thompson Memorial Prize Award in December, for the most outstanding paper in any IEEE publication by a young author. Parhi's paper, "Algorithm Transformation Techniques for Concurrent Processors," was published in the special issue of *The Proceedings of the IEEE on Supercomputer Technology* in December 1989. Six new faculty members joined the department fall quarter: assistant professor ***S. Dutt***, University of Michigan; assistant professor ***M. O'Keefe***, Purdue; assistant professor ***J. Moon***, Carnegie Mellon; assistant professor ***R. Harjani***, Carnegie Mellon; assistant professor ***J. Zhu***, University of California—San Diego; and associate professor ***J. Leger***, MIT Lincoln Laboratory.

Mechanical Engineering
Professor ***Arthur G. Erdman*** served as Visiting Chair Lecturer at the National Science Council of the Republic of China in Taiwan, November 8-14, 1990. Visiting lectureships are offered to world-renowned scholars and scientists. Professor ***Edward A. Fletcher*** has been named to a three-year appointment as Visiting Scientist with the rank of professor in The Department of Environmental Sciences and Energy Research at the Weizmann Institute of Sciences. ***Richard J. Goldstein***, Regents' Professor, James J. Ryan Professor, and department head, received the A.V. Lykov Medal for his outstanding contributions to the science and art of heat and mass transfer and notable contributions to international scientific cooperation. ***David L. Hofeldt***, who received his doctorate from Stanford University, joined the department as assistant professor in December 1990. Professor ***Edwin T. Layton*** was awarded the Society for the History of Technology's highest honor, the Leonardo Da Vinci Medal, for 1990. Layton was cited for the contributions he has made through his articles and a book, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*. Professor ***Subas V. Patankar*** received the Governor's Award—Asian-Pacific Community November 1, 1990. The award honors outstanding members of Minnesota's Asian-Pacific community. I

PREVIEW

The entrepreneurial spirit

More than 175 companies have been founded by IT alumni, ranging from local one-person operations with annual sales of thousands of dollars to multi-national conglomerates with annual sales in the billions.

In the next issue of *ITEMS*, we'll introduce you to some of IT's most entrepreneurial alumni. You'll learn the stories behind the birth of their businesses and a few secrets that may help you start your own. I

Global change

Is the greenhouse effect really raising atmospheric temperatures, or are we simply witnessing a normal "peak" in cyclical changes in our climate? In September, we'll examine the controversy surrounding global change and bring you up to date on the latest research and expert opinion. I

Infrastructure
continued from page 15

sense, that's what America did when it built its elaborate infrastructure of roadways, bridges, and sewer systems—it forgot to make adequate allowances for maintaining and managing those investments.

"I don't see a day ahead of collapse," says Linzie. "Not yet. But, I don't see a day where the public will decide to spend the money necessary to satisfy all our needs either. So, we're going to have to struggle to make good decisions on where our needs are the greatest and how we spend that money."

As with many struggles, coping with the problem of our now-crumbling foundations has led to a certain amount of procrastination. But, those days are gone, says Braun. "It is a problem with which we must contend now." And, he does not speak idly by any means. From sewers, to bridges, to highways, to traffic concerns, he and his colleagues at the Institute of Technology have a jump start in not only determining which of our needs are the greatest, but in designing bigger, better, and stronger infrastructure systems upon which our nation's future can solidly rest. I

Maggi Aitkens is a freelance writer living in Minneapolis.

ALUMNI

1922

Reuben B. Ellestad *(Chemistry, 1924 M.S., 1929 Ph.D.)* retired in 1974 from the Lithium Corporation of America (now FMC-Lithium Division). Ellestad, who lives in Gastonia, N.C., received the Charles H. Stone Award from the Carolina-Piedmont Section of the American Chemical Society in 1972.

1928

Percy A. Wells *(Chemistry)* retired in 1969 from his position as director of the Eastern Regional Research Center of the U.S. Department of Agriculture. Wells received his master's degree in chemistry from George Washington University in 1932 and his doctorate in biochemistry from Georgetown University in 1939. Wells, who lives in Abington, Pa., has received several awards, including the Honor Award from the American Institute of Chemists in 1952 and the District Service Award from the USDA in 1956.

1930

Onni Lindfors *(Electrical)* retired from Fairbanks Morse in 1972 and is living in Beloit, Wis. **Reuben E. Wald** *(Electrical Engineering)* retired in 1970 and is living in Cornelius, Ore.

1931

Paul A. Marksun *(Electrical)* retired as president of Van Bergen and Marksun in 1982 and is living in Minneapolis. **Joseph W. Skovholt** *(Electrical)* retired in 1973 from Honeywell Inc. Skovholt, who lives in St. Paul, was named to the Theta Tau Hall of Fame. He served as president of the St. Paul Engineer's Society.

1935

Albert B. Savage *(Chemistry and Chemical; Chemical, 1937 M.S.)* retired from Dow Chemical Co., Michigan Division, in 1976. Savage, who lives in Midland, Mich., holds 26 U.S. patents and several foreign patents.

1936

David I. Buck *(Mechanical)* retired in 1977 as a sales engineer for General Electric Co. and is living in El Paso, Texas. **William D. Schoell** *(Civil and Mineral)* retired in 1986. Schoell, who lives in Deephaven, Minn., was a consulting engineer who founded three companies: Schoell & Madson, Inc.; Schoell, Fields & Assoc.; and Carbonair Services, Inc. His company, Schoell & Madson, Inc., has received several citations from the Minnesota Consulting Engineers Council and the American Consulting Engineers Council for engineering excellence on various projects.

1937

Carl R. Henrici *(Electrical)* retired in 1981 and is living in Cedar Rapids, Iowa. **Robert Berg Rhode** *(Civil and Mineral)* retired in 1978 as chief engineer for the Duluth, Missabe & Iron Range Railroad Co. Rhode, who lives in Duluth, served on the national board of directors of the American Society of Civil Engineers from 1979 to 1982.

1938

Ralph J. Muller *(Mechanical)* retired in 1986 and is living in Buffalo, Minn. He operated Muller Sales, a manufacturers' representative firm.

1939

John W. Pearson *(Chemical)* is president and CEO of Video Training Resource, Inc., a Minneapolis firm he co-founded in 1984. He also operates Pearson Consulting Co., a management consulting firm. Pearson holds several patents assigned to 3M. He received the 3M Carlton Society Award, the Engineering Achievement Award, the University of Wisconsin-Stout J.R. Johnson Award, and the National Council of Engineering Examiners Distinguished Service Award. **Edward D. Pierson** *(Mechanical)* of Denver, Colo., retired in 1971. Pierson founded Miner-Denver Inc. in 1954, a machinery design and manufacturing company.

1940

William S. Mitchell *(Chemical)* retired in 1988 and is living in Minnetonka. **Ralph W. Rogers, Jr.,** *(Chemical)* retired as section head for Alcoa Research Laboratories in 1983. Rogers, who currently lives in Momosassa, Fla., received his master's degree in metallurgy from Michigan State University in 1942. **Bernard I. Sather** *(Mechanical)* retired from NASA in 1980. Sather, who lives in Westlake, Ohio, earned his master's degree in mechanical engineering from Case Institute of Technology in 1947. **William I. Weisman** *(Chemical)* retired as president of the Ozark-Mahoning Co., Tulsa, Okla., in 1983 and is living in Tulsa. **Sidney J. Wolfenson** *(Electrical)* currently works part time as a consultant for Wolfenson Electric Inc., an industrial electrical contracting firm he founded in Houston, Texas, in 1959.

1941

Clarence W. Huffman *(Chemistry, Ph.D.)* retired as manager of chemical research for IMCERA in 1976. Huffman, who earned his bachelor's degree at Ripon College, lives in Glenview, Ill. He has received alumni awards both from his high school and Ripon College. He holds several patents and is the author of numerous technical articles. **Herbert C. Lindstrom** *(Aerospace)* is the owner of Minvalco Inc, a Minneapolis wholesale distributor of automatic controls. Lindstrom, who lives in Minnetonka, formerly worked for Pratt & Whitney Aircraft.

1942

Richard A. Johnson *(Aerospace)* retired from The Boeing Company in 1985 where he had worked as manager of technical integration for aircraft. Johnson, who lives in Seattle, Wash., was an engineering manager on all models of Boeing commercial aircraft. **Robert M. Johnson** *(Mechanical)* retired in 1987 as associate project engineer/department manager for the John Graham Company. Johnson, who lives in Bellevue, Wash., also served on the Washington State Building Code Council. **Thomas L. Keller** *(Aerospace)* retired in 1987 from Grumman Aerospace Corp. where he had worked as a senior staff scientist. He currently lives in Fort Collins, Colo. **Frederick J. Reinarz** *(Mechanical)* retired from Donaldson Company, Inc. in 1983 where he had served as engineering standards supervisor. Reinarz lives in Bloomington, Minn. **Robert V. Rosenwald** *(Mechanical)* retired from Honeywell, Inc. in 1985 and is living in Danbury, Wis. Rosenwald received an award for technical accomplishments and outstanding contributions to the Ring Laser Gyro Program from the Honeywell Avionics Division.

1944

Raymond L. Grismer, Jr., *(Mechanical)* retired from General Electric Company in 1989 as manager of airline sales. Grismer lives in Cincinnati, Ohio. **Daryl G. Mitton** *(Chemical; 1948 M.B.A.; Business Administration, 1953 Ph.D.)* is director of the Entrepreneurial Management Center and professor of management at San Diego State University. Mitton was named Entrepreneur of the Year for San Diego in 1988 and received the Edwin M. Appel Award for Entrepreneurial Excellence from Price Institute for Entrepreneurial Studies in 1990. **Paul A. Rebers** *(Chemical, 1946 M.S.; Agricultural Biology, 1951 Ph.D.)* retired in 1988 from the Ames, Iowa, Office of the United States Department of Agriculture where we worked as a chemist.

1945

LeRoy C. Horpedahl *(Mechanical)* retired in 1987 from the Los Alamos National Laboratory and is living in Los Alamos, N.M. **Walter E. Strimling** *(Physics; Mathematics, 1945 M.S., 1953 Ph.D.)* is president of United States Dynamics, a manufacturing firm founded by Strimling in Waltham, Mass., in 1955.

1947

Rollyn W. Frank *(Electrical)* owns a petroleum consulting firm, R.W. Frank, Consultant, in Dallas, Texas. **John R. Hed** *(Aerospace)* retired in 1980 after nearly 40 years of military service with the Air National Guard (where he was chief of aircraft maintenance), the Army Air Force, United States Air Force, and the Army Air Corps. Hed, who lives in Duluth, was a pilot while in the service and was a member of the Soaring Society of America. He currently belongs to the Experimental Aircraft Association. **Michael J. Joncich** *(Chemistry)* is retired and living in Oak Ridge, Tenn. Joncich earned his master's degree in chemistry in 1950 from Oregon State University and his doctorate in 1953 from the University of Texas. He was professor and head of the department of chemistry at Northern Illinois University and published more than 30 articles in professional journals. **Robert G. Lunche** *(Chemical)* retired in 1976 and currently works as an independent air quality consultant. Lunche lives in Hacienda Heights, Calif.

1948

Clifford L. Peterson *(Mechanical)* retired in 1989 as manager of engineering from the Mead Corp.-Chillicothe Mill. Peterson lives in Chillicothe, Ohio. **Donald R. Satrom** *(Civil and Mineral)* retired from Fidelity Union Bank Corp. and is living in Bentonville, Ark.

1949

George S. Arneson *(Electrical)* is president and founder of Arneson & Company, a management consulting firm in Leawood, Kan. **J.E. Colcord** *(Civil and Mineral, M.S.)* is a professor emeritus at the University of Washington and lives in Seattle. **Paul A. Johnson** *(Mechanical)* retired in 1986 as director of purchases/operations for 3M. Johnson lives in Chisago City, Minn. **Sidney M. Martinson** *(Electrical)* retired in 1987 from Northern States Power Co. and lives in Crystal, Minn. **Arnold P. Smith** *(Electrical)* retired from Northrop Corp. Defense Divsion in Rolling Meadows, Ill., and is living in Mt. Prospect, Ill.

1950

Charles N.S. Ballou *(Chemical)* retired from Sherex Chemical Corp. in 1987 and is living in Gahanna, Ohio. **David B. Ballou** *(Mechanical)* retired in 1978 after serving 31 years in the United States Air Force and is living in Spokane, Wash. Ballou was a fighter pilot and achieved the rank of colonel. **Henry D. Barbour** *(Mechanical)* retired from Thermo King in 1985 and is living in Holmes Beach, Fla. **Lloyd H. Bergmann** *(Electrical)* retired in 1987 and is living in Winston-Salem, N.C. Bergmann had worked with the military groups of both Honeywell, Inc. and Westinghouse Electric. **Arthur F. Christensen** *(Mechanical)* is principal engineer for Bask-Robbins USA Co. Christensen lives in Valencia, Calif. **John A. Gernert** *(Civil and Mineral)* retired in 1981 as general superintendent/mining engineer for M. A. Hanna Co. Gernert lives in Iron Mountain, Mich. **Carl W. Glewwe** *(Electrical, 1955 M.S., 1958 Ph.D.)* is vice president of Lynn Services, Inc. in St. Paul. **Preston C. Haglin** *(Civil and Mineral)* retired in 1983 from the building construction firm he founded, Preston Haglin Co. Haglin works part time as a consultant and lives in Minneapolis. **Palmer O. Hanson, Jr.,** *(Mathematics)* retired in 1989 as a senior engineering fellow for Honeywell, Inc. Hanson, who lives in Largo, Fla., received the H.W. Sweatt Award from Honeywell. **Douglas A. Kohl** *(Electrical)* retired in 1988 and

Out of defeat, victory

The way a person responds to adversity and defeat is said to be a true test of character. It is not surprising then that Carl Nomura has achieved the many successes he has. He took that test—and passed it—early and often during his life.

The son of Japanese immigrants, Nomura was born "somewhere between Deer Lodge and Three Forks, Montana," in 1922. His family moved to California when he was five. The following year his father died, leaving behind several debts and eight children. The hard times that followed forced Nomura and his family to take whatever work was available.

When he was in the 10th grade, Nomura's algebra teacher took him aside and advised him not to take geometry because he would be taking a seat from a more deserving student. She also told him he was a person of limited abilities and should enroll in classes such as wood and auto shop where he could learn to do things with his hands.

Instead of following her advice, he decided to master algebra—along with trigonometry, solid geometry, and Latin. The teacher who gave him no hope eventually found herself giving him "A's" on his assignments.

The shock of being pigeonholed as a poor student, however, paled in comparison to what awaited Nomura in the years following his graduation from high school in 1941. As a Japanese American, Nomura was interned in the Manzanar Relocation Center during the period of panic and paranoia that followed the bombing of Pearl Harbor. After his release, Nomura applied to nearly 20 colleges and universities around the U.S., most of which turned him down because of his Japanese ancestry. But the University of Minnesota Institute of Technology accepted him, and he began attending classes in the fall of 1944. The winds of World War II were not yet through with him, however.

In December 1944, Nomura was drafted into the U.S. Army. "They didn't know what to do with me, so they put me in the Reserves," he says. He was sent back to Manzanar to wait until he was called to active service. In 1945, he was called to service at Fort Douglas, Utah, where, as Nomura recalls, a woman spit in his face. In 1946, he was discharged and returned to the University.

The welcome he received at IT was particularly heartwarming, Nomura recalls. Friendships that were to last a lifetime were initiated. He received his bachelor's and master's degrees in physics in 1948 and 1949, respectively, and stayed on at IT to earn his Ph.D. degree in electrical engineering in 1953.

Upon graduation, Nomura took a job with Honeywell, Inc as a research scientist. Although he thought he would stay in research for most of his career, after eight years he was promoted to management and proceeded to climb the corporate ladder all

Carl Nomura

the way to Corporate Senior Vice President—the position from which he retired in 1986.

Nomura was noted not only for his spartan office decor—consisting of a round cafeteria table and four chairs—but for his strong people skills as a manager. His successful management style included praising his employees lavishly for their accomplishments—in front of their peers if appropriate—and not conducting witch hunts when things went wrong. "Accidents do happen," Nomura says, "and the person who was in the wrong knows there was a problem and ultimately will not repeat the error."

Through much of his career, Nomura worked to provide opportunities for employees to succeed, to make room for women and other minorities, and to eliminate unfair perks and advantages offered to high-ranking employees. He played an integral role in the development of Honeywell's Solid State Electronics Division and several very successful products, including the Hall Sensor. Some two billion Hall Sensors were used in computer and data entry keyboards, and later, the device was adapted for use in automobile ignition systems, eliminating the need for contacting rotors and capacitors.

The respect and admiration Nomura had earned during his career at Honeywell became evident at the time of his retirement. Instead of the typical gold watch, friends and colleagues pooled their resources and presented him with a boat and trailer which they wheeled into the room during his retirement party. In addition, Nomura was presented with a sterling silver plate commemorating his 33-year career at Honeywell. "Carl has made a greater contribution to the success of Honeywell than any other executive in the company," said Edson W. Spencer, Honeywell's chief executive officer, at the time of Nomura's retirement. In 1988, the University of Minnesota presented Nomura with the Outstanding Achievement Award.

Today, Nomura lives in Port Townsend, Wash. He describes himself as a part-time garlic farmer, but spends much of his time raising funds for a scholarship program for the children of Southeast Asian Refugees.

"This project appeals to me because, although there were racists and power-hungry people who put us away, there were good people who reached out to help us," Nomura says. "Because of the quality and compassion of its leadership, the U of M ranks number one in my book." I

Lessons from the farm

As the son of a southern Minnesota farmer living near Pemberton, Minn. (just south of Mankato), Larry Adams had plenty of opportunities to learn about hard work and responsibility at an early age. Money was tight and the demands of running a 280-acre farm drew the whole family into the work force. At age 12, Adams was given responsibility for a team of four horses and a rig, and at age 16 (after graduating from high school early) he began farming on his own. After four years of farming, however, Adams decided there had to be an easier way to make a living, so he packed his bags and set off for the University of Minnesota.

The lessons Adams learned down on the farm prepared him well for the road ahead—especially insofar as concerned a sense of personal responsibility. After just two quarters studying metallurgy, Adams was forced to leave the University and return home; his father was sick and his brother had been drafted to serve in World War II. When his father passed away the following spring and his brother was released from service on a hardship leave, Adams enlisted in the Navy. In March 1944, he got his wings as a naval aviator and was assigned to the operations squadron on

lives in Osseo, Minn. In 1974, Kohl founded Sparsa Products Inc., a firm that produced severe weather instrumentation. Kohl, who received a special service award from the National Weather Service, holds 15 patents and has published 38 technical papers. **Berthus B. McInteer** *(Physics, Ph.D.)* retired from Los Alamos National Laboratory in 1987 and is living in Los Alamos, N.M. In 1983, he founded Isotope Services Inc, an analytical services firm. **Harold S. Winston** *(Civil and Mineral)* owns and operates Rabwin Oil & Gas, Inc., a petroleum exploration and production firm in Fort Worth, Texas.

1951

David T. Blazevic *(Mechanical)* is president of Hot Rolling Consultants, Ltd., a firm he founded in 1982 to provide consulting services to steel mills. Blazevic, who holds three patents on steel rolling processes, lives in Olympia Fields, Ill. **Richard J. Reilly** *(Aerospace)* is president of Cuyuna Corp., an engineering consulting firm he founded in 1979. In 1963, Reilly received the U.S. Air Force Systems Command Award. He holds 18 patents.

1952

Alvin J. Mathy *(Aerospace)* retired in 1990 from The Boeing Company as chief engineer E-8 airplane program. He recently incorporated his own aeronautical engineering consulting firm, A. J. Mathy & Associates, Inc. Mathy lives in Mercer Island, Wash.

1953

Walter P. Miller *(Chemistry, 1957 Ph.D.)* is a health and product safety manager for UCAR Emulsion Systems, a subsidiary of Union Carbide Corp. Miller lives in Raleigh, N.C. **Thomas E. Vavra, III,** *(Civil and Structural)* is president and founder of Vavra Architects—Engineers, Inc. in Milwaukee, Wis. Vavra is also a retired lieutenant commander in the U.S. Naval Reserve (Civil Engineering Corps).

1954

Edward H. Dewes *(Mechanical)* is engineering supervisor of a military design group for Allison Transmission Division of General Motors Corporation in Indianapolis, Ind. **Peter A. Fischer** *(Civil and Mineral, 1955 M.S.)* is an independent consulting engineer in Maplewood, Minn. Fischer received two Department of the Army decorations for Meritorious Civilian Service and was named 1986 Engineer of the Year by the U.S. Army Corps of Engineers.

1955

Frederick C. Bereswill *(Aerospace)* is an air safety investigator for The Boeing Company in Seattle, Wash. **John B. Smith** *(Mechanical)* is owner and president of Gopher Sign Company in St. Paul.

1956

John D. Luhman *(Electrical)* is retired and living in Fridley, Minn. **Harvey A. Ramlow** *(Civil and Mineral)* is principal engineer in the Physical Planning Department at the University of Minnesota.

1957

John J. Davis *(Electrical)* is program manager for Lake Center Industries in Winona, Minn. **Melvin F. Kanninen** *(Mechanical, 1959 M.S.)* is an institute scientist for Southwest Research Institute in San Antonio, Texas. Kanninen, who earned his doctorate in 1966 from Stanford University, was elected to the National Academy of Engineering, is an ASME Fellow, and has authored 150 papers and one book. He has also edited six books. **Ramond E. Lind** *(Civil and Mineral)* is northwest regional engineer for the Minnesota Department of Natural Resources in Bemidji, Minn. **Allen M. Palo** *(Electrical)* retired in 1989 from Honeywell, Inc. where he worked as a consultant. Palo lives in Prescott, Ariz.

1958

Willard H. Beattie *(Chemistry, Ph.D.)* retired in 1989 from Los Alamos National Laboratory where he worked as a research chemist. **Howard L. Stensrud** *(Geology)* is professor of geology and department chair at California State University, Chico. He received his master's degree in geology from the University of Wyoming in 1963 and his doctorate in geology from the University of Washington in 1970.

1959

Gary A. Andersen *(Electrical)* is president and CEO of RF Monolithics, Inc. of Dallas, Texas. **Donald R. Mittelstadt** *(Electrical)* is vice president of SMA Inc., Minneapolis. He was elected a Fellow of the American Society for Quality Control in 1973. **William C. Summers** *(Mechanical; Zoology and Industrial Engineering, 1966 Ph.D.)* is a professor at Huxley College of Environmental Studies at Western Washington University.

1960

Frank E. King *(Electrical)* is principal electrical engineer of facilities for Unisys Corp. in St. Paul. **Danno F. Mahoney** *(Electrical)* is president, CEO, and owner of Crosby Manufacturing Co. in Crosby, Minn.

1961

William J. Billett *(Mechanical)* is a senior mechanical engineer for Weigh-Tronix in Fairmont, Minn. In 1985, Billett received the Silver Award from the James F. Lincoln Arc Welding Foundation for advancement of arc-welded design, engineering, and fabrication. 1985. He also developed a patented trigger mechanism for the U.S. Army. **Roy F. Holm** *(Mechanical)* is a senior engineering specialist for 3M and lives in Roseville, Minn. **David B. Jackson** *(Electrical)* is director of programs for Honeywell, Inc. Jackson, who lives in Deephaven, Minn., won the Honeywell H.W. Sweatt Award in 1967 and has published several technical papers on aerospace guidance and control. **John B. Rosandich** *(Chemical)* is a senior engineering associate for Exxon Research and Engineering Co. in Florham Park, N.J. **James W. Schneider** *(Aerospace)* is an advisory systems engineer for IBM in Minneapolis. Schneider earned his M.B.A. degree from the University of Santa Clara in 1965. **David J. Selvig** *(Aerospace)* is an engineering manager for The Boeing Company in Seattle. **Theodore P. Trampe** *(Chemistry)* is a senior industrial engineer for the Gillette Co. in St. Paul. Trampe and his wife, Carmen, were co-founders and directors for 12 years of HOPE International Family Services, a not-for-profit private adoption agency still operating in Stillwater, Minn.

1962

James W. Button *(Electrical)* retired in 1986 and is living in Woodbury, Minn. **Robert J. Conlin** *(Electrical)* retired in 1989 and is living in Chippewa Falls, Wis. Conlin founded two companies still in operation, Automation Displays Inc. (a manufacturer of graphic displays and controls) and Video Monitors Inc. (a manufacturer of high-resolution monitors). Conlin was named Small Business Man of the Year for Eau Claire, Wis., in 1983. **Frank J. Ferrin** *(Electrical, 1969 M.S.)* is a senior engineering fellow for Honeywell, Inc. in St. Louis Park, Minn. Ferrin holds three patents and received the H. W. Sweatt Award from Honeywell in 1979. **Alan M. Hansel** *(Electrical)* is founder and president of Southern Minnesota Communications Inc., a two-way radio sales and service firm in Waseca, Minn. **Robert A. Kierlin** *(Mechanical; 1964 M.B.A.)* is president and CEO of Fastenal Company, a wholesale distribution firm he founded in Winona, Minn., in 1967. **James A. Kvikstad** *(Chemical)* works in technical service for 3M in St. Paul. He earned his master's degree in chemical engineering from the State University of New York in 1969. **Roger A. Kyllo** *(Electrical)* is engineering department manager for Rockwell International in Cedar Rapids, Iowa. He is a co-holder of a patent for an adaptive communication device. **Lloyd L. Roberts** *(Physics)* retired in 1990

an antisubmarine aircraft carrier in the Atlantic.

After the war, it was back to the books and the University, where Adams entered the aeronautical engineering program. The GI Bill—which Adams calls "the smartest thing the government ever did"—eased the financial strain of attending college, but Adams was eager to complete his education and took on a course load (19-22 credits per quarter) that kept things interesting. "One quarter I had to write seven term papers," Adams says. "It was an intense experience."

After receiving his bachelor's degree in aeronautical engineering in 1948, Adams began working for Martin Marietta in Baltimore as a stress analyst in the company's pilotless aircraft (missile) division. There, the farm boy from Pemberton quickly made an impression and climbed up through the company ranks. He served as technical director of the Titan 3 missile development program, in which he directed the work of more than 1,500 engineers, and in 1976, he was promoted to president of Martin Marietta's aerospace operations. He became chief operating officer of the corporation in 1982, and just one year later, its president and chief operating officer—a title he held until he retired in 1986.

Since retiring, Adams has served as a consultant to various private and governmental agencies. He is a member of the NASA Advisory Council, chair of its Space Station Advisory Committee, and a member of the Air Force Scientific Advisory Board. He also is a member of the National Academy of Engineering. In 1970, Adams received the University of Minnesota Outstanding Achievement Award.

Adams lives in Potomac, Maryland, where he pursues his numerous hobbies and activities. He is concerned about some of the challenges confronting the nation.

"America faces a challenge finding the right balance between social programs and programs that foster economic and technical strength," says Adams. "At present, the pendulum has shifted too far in the direction of social programs."

"We need more programs that will get our young people excited: a NASA space station or a super-conducting super-collider," Adams says. "We especially need to understand Earth's environment. We need to invest in things that will make us better for the future."

And though he attributes some of his personal success to luck—along with a good measure of self confidence, and analytical skills and other attributes—Adams has a few words of advice to offer young graduates entering the work force today:

"Select the place where you are going to work very carefully. It should be a strong organization with good people. The work should be interesting and something you think is fun. Figure out how to get along with people. Practice treating everyone like a human being—people will generally respond. Many great individual achievers have not made it because they could not work well with people."

But most importantly, Adams suggests, "Work hard and develop a healthy attitude." It's worked for him. I

The lion of Lyondell

When Bob Gower took over as president of Lyondell Petrochemical Company in Houston, Texas, in April 1985, he was confronted with what he describes as "the greatest challenge of my life." With a string of 39 consecutive losing months behind it, the firm was on the verge of collapse. The balance sheet for the previous fiscal year alone showed some $200 million in losses.

"The clock was ticking," Gower says. "We had only a few months to show significant improvement. We had to get at least to

IT DONOR PROFILE

Richard and Helen Swalin

Home:
Tucson, Arizona

Career:
The Institute of Technology has been a large part of Dr. Richard Swalin's life for over 43 years. A native of Minneapolis, he earned his bachelor's degree and doctorate in metallurgy from IT in 1951 and 1954 respectively. After a two-year stint with General Electric Research Lab in Schenectady, N.Y., IT recruited him to pursue what was to become a long and accomplished academic career. Through 1977, his titles included professor of metallurgy, head of the School of Mineral and Metallurgical Engineering, and dean of IT. He left the Institute to become vice president of Eltra Corp. in 1977, and two years later, when Eltra Corp. was acquired by Allied Chemical, he moved to the rank of vice president of R&D for that company. In 1984, however, he decided to return to academia—this time at the University of Arizona where he became dean of Engineering and Mines. Currently he is on leave of absence from that university to develop a course on technology and society. A father of three, Swalin met his wife, Helen Van Wagenen, at the University where her father was a professor.

Recent Gift:
Swalin recently donated a large portion of a million dollar life insurance policy, which he holds through a directors' Corporate Contribution Plan offered by one of his companies.

Quote:
"I am well aware of how important private support is to the Institute, which receives only 45 percent of its funding from the state. When one of the companies where I'm a director instituted a contribution plan for its directors, I used the opportunity to help IT."

from McDonnell Douglas Corp. where he was principal engineer of aircraft systems engineering. Roberts lives in Huntington Beach, Calif. **Roland E. Weber** *(Electrical, 1964 M.S., 1967 Ph.D.)* is president of Applied Biometrics, a medical diagnostics firm he founded in 1985. He also founded Physical Electronics, an analytical instruments firm, in 1969.

1964

Matthew J. Cunningham *(Physics, 1971 M.S.)* is a systems analyst for the City of Minneapolis. Cunningham received the City of Minneapolis' "Excelebrate the Best of Us" Award from the mayor and City Council president in 1990. **James W. McCarville** *(Chemical; 1972 M.B.A.)* is manager of information architecture for manufacturing systems at 3M in St. Paul. McCarville received the Chapter Engineer of the Year Award from AIIE in 1984. **Bruce R. Meyer** *(Mechanical)* is president of Daytons Bluff Sheet Metal in St. Paul. **Jared C. Scofield** *(Mechanical; Civil and Mineral, 1966 M.S.; 1986 M.B.A.)* is assistant vice president and trust investment portfolio manager for First Interstate Bank of Arizona in Phoenix. **William L. Shaffer** *(Geology)* is a general partner of GHD Resources and vice president of Shoreham Resources, two mining firms in El Paso, Texas. Shaffer earned his master's degree in geology from the University of New Mexico in 1971.

1965

Patrick D. Holiday *(Electrical)* owns Product Development & Marketing, a consulting firm in Waco, Texas. **Joel D. Kuyper** *(Mechanical)* is a senior combustion engineer for Armco Steel Co. L.P. in Ashland, Ky. **Robert G. Lindgren** *(Chemical)* is a senior scientist for Arete Associates in Sherman Oaks, Calif. Lindgren earned his Ph.D. degree in chemical engineering from the California Institute of Technology in 1970. **Richard M. Mullenbach** *(Electrical)* is manager of reliability engineering for Cardiac Pacemaker and lives in New Brighton, Minn.

1966

James A. Benshoof *(Civil and Mineral)* is the founder and president of Benshoof & Associates, Inc., a traffic engineering consulting firm in Eden Prairie, Minn. Benshoof earned his master's degree in transportation engineering in 1968 from Northwestern University and his master's in traffic engineering from the University of Newcastle Upon Tyne, England, in 1969. **Rolf S. Bergman** *(Electrical, 1968 M.S., 1972, Ph.D.)* is chief scientist in lamp technology for General Electric Company in Cleveland, Ohio. **Peter W. Dahl** *(Electrical)* is president and CEO of Peter W. Dahl Co. Inc., a transformer manufacturing firm he founded in El Paso, Texas, in 1977. Dahl was named Small Business Person of the Year in 1986 by the El Paso Chamber of Commerce and the local office of the Small Business Administration. **Richard W. Thimijan** *(Agricultural Engineering, M.S.)* retired in 1989 and is living in College Park, Md. He was an agricultural engineer for the United States Department of Agriculture.

1967

Leroy D. Sturges *(Aerospace, 1975 M.S., 1977 Ph.D.)* is associate professor of engineering mechanics at Iowa State University in Ames, Iowa.

1968

Bernie R. Bullert *(Civil and Mineral; 1977 M.B.A.)* is field division manager for St. Paul Water Utility.

1969

Robert J. Yourzak, P.E., *(Civil and Mineral)* is president of Robert Yourzak & Associates, an engineering and project management consulting firm in Minneapolis. Yourzak earned his master's degree in civil engineering in 1971 and his master's of business administration degree in 1975, both from the University of Washington. He received the Edmund Friedman Young Engineer Award from ASCE in 1979.

a break-even point within nine months. Many people thought we couldn't do it. Fortunately, they didn't work for us. We thought we could."

Gower and his management team believed in the company and believed in themselves. "They were people who know how to get results, people who expect to succeed," he says. But the months ahead were fraught with difficult decisions.

The magnitude of Lyondell's losses meant severe cutbacks would be needed to effect a turnaround. Annual operating expenses were trimmed by $100 million through a 30 percent cut in the work force. Four layers of management were removed as well. "Over management is one of the worst sins in business," Gower says. "It destroys employee incentive."

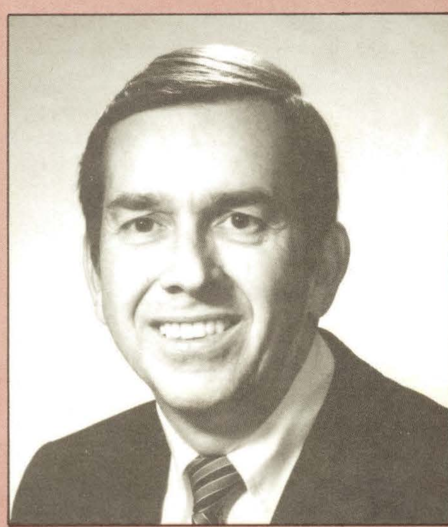
Within two weeks, Gower and his team of managers outlined their goals and met with employees to discuss management style, which included a lean management team with "no frill groups to massage the egos of top management and no staff assistants to make managers feel important."

"Employees do not expect managers to be brilliant, but they do expect them to be honest," Gower says. "You can't ask employees to continually cut costs and then have the managers arrive in limos or corporate jets."

By the end of the year, Lyondell had reached the break-even point. In the years since, the company has shown a cumulative profit of roughly $1.4 billion—a remarkable turnaround engineered by a man with no formal business education.

The fact that Gower succeeded so famously can be attributed to a lifetime of firsthand experience in business and business management. At his mother's suggestion, Gower became an independent businessman at the tender age of 12 when he started a business to manage the upkeep of family plots at the local cemetery in West Frankfurt, Illinois, where he grew up. For the next several years, he trimmed trees, cut grass, filled in sunken graves, and repaired damaged headstones, maintaining the business right through his years as an undergraduate at Southern Illinois University (SIU).

When he completed his bachelor's degree in chemistry in 1958, Gower received several job offers, none of which interested him. Instead, he enrolled in the newly created master's program



Bob Gower

at SIU, earning his degree in 1960. Gower then enrolled in the doctoral program in organic chemistry at the University of Minnesota. His thesis advisor, professor Edward Leete, gave Gower a lot of freedom and a reasonable amount of guidance—the perfect mix, according to Gower—to help him develop his self-confidence.

In 1963, after receiving his Ph.D., Gower went to work for Sinclair Oil Corporation as a research scientist. After a few years, however, he decided he couldn't achieve what he wanted by staying in research. During the next several years, Gower worked at a number of positions within the company to acquire the skills that come with an MBA without having to go back to college. He worked in sales for a year, moved on to marketing, and then served as head of a project to design, construct, and begin operation of 40 completely automated gasoline stations. He then worked in retail gasoline marketing before returning to research in 1974.

With his "MBA-in-the-field" training, however, Gower was soon drafted into the management of Atlantic Richfield, which merged with Sinclair in 1969. He became vice president of ARCO Chemical Company in 1977 and senior vice president in 1979. In 1984, he was elected senior vice president of Atlantic Richfield, responsible for planning and advanced technology for the corporation. Then, in 1985, he was named president of Lyondell.

Today, Lyondell is listed in the Fortune 500 rankings. In 1989, the firm was 93rd in sales, 72nd in profits, 5th in return on assets, and 1st in sales per employee.

His experience with Lyondell led Gower to offer the following suggestions for young IT graduates who want to start their own businesses: get experience as broadly as possible in the first five years; never think the technical side is the most important part of a business—sales, manufacturing, and marketing are just as critical; and, be very flexible and learn what the customer needs.

There are many components to the guidelines Gower developed to effect Lyondell's turnaround, but among the most poignant are Gower's beliefs about the importance of maintaining one's integrity when choosing a course of action.

"Would I be willing to discuss my action with my wife and three daughters?" Gower asks. "Would it be what I want my daughters to do in their careers? If not, it fails the test, and I don't do it. That's how simple integrity is. It's doing what you believe to be the right thing. It's doing what you are willing to have fully exposed." I

Doing what needs to be done

Precisely at 9:00 a.m., Ray Johnson shows up for work at Mayon Plastics, Inc, carrying a brown bag lunch and wearing gray dockers, loafers, and a baby-blue, cotton-cabled sweater. By the time he leaves work at 1:00 p.m., the elbows of his sweater will be smudged with carbon.

He walks to his desk in the far right corner of a large room that acts as both reception and office space. He answers the phone in a friendly voice and helps a customer figure out his plastic tubing needs. When he's finished, he tosses the order on one of the many piles on his desk and quickly reels a sheet of letterhead into his typewriter and composes a letter. As owner and part-time president of Mayon Plastics, it's evident that 73-year-old Johnson doesn't let his title get in his way; he does whatever needs to be done.

That seems to be the approach he has taken through much of his life. When he entered the University of Minnesota in 1935, he immediately joined the professional chemistry fraternity, Alpha Chi Sigma, and tackled his studies with no holds barred. Carrying an academic load of 17 to 23 credits each quarter, he studied most evenings until midnight and allowed himself only one night a week for fun.

He had once read an article that said home economists made the best wives and chemical engineers made good husbands. So

1970

Michael R. Heller *(Chemical)* is a senior production engineer/system engineer for Northern States Power Co. in Welch, Minn. **Dale H. Otterness** *(Mechanical)* is a mechanical engineer for the U.S. Army Corps of Engineers in Washington, D.C.

1971

Paul R. Glamm *(Mechanical, 1974 M.S.)* is a development engineer for The Trane Co. in La Crosse, Wis. Glamm holds several patents on refrigeration systems and controls. **Dennis S. Klohs** *(Aerospace)* is an owner of Cornwell-Klohs Co., a real estate development firm in Edina, Minn. **Robert C. Uebelacker** *(Mechanical)* is a pilot and test manager for the United States Air Force. Uebelacker received his M.P.A. degree from the University of Northern Colorado in 1978.

1972

Kerry R. Field *(Physics)* is a product manager for 3M in St. Paul. **James H. Krech** *(Civil and Mineral)* is a structural engineer for Krech, Obrien, Mueller & Wass, an Inver Grove Heights architectural and engineering firm he co-founded in 1985. **Kurt D. Thomforde** *(Mechanical)* owns and operates a farm near Goodhue, Minn. **Allen E. Windhorn** *(Electrical)* is a principal engineer in controls design for Kato Engineering in North Mankato, Minn.

1973

John E. Edmunds *(Civil and Mineral)* is a civil engineer III for the City of Minneapolis. Edmunds accepted the Minneapolis Aquatennial Public Service Award for the Public Works Department in 1990. **Mark L. Gravley** *(Chemical)* is a senior research engineer for Phillips Petroleum Company, Bartlesville, Okla. He is the inventor or co-inventor listed on several U.S. and foreign patents.

1974

Harmon B. Abrahamson *(Chemistry)* is an associate professor of chemistry at the University of North Dakota. Abrahamson earned his Ph.D. degree in inorganic chemistry from the Massachusetts Institute of Technology in 1978. **Robert W. Fennell** *(Chemistry, M.S.)* is an engineering data manager for Dayco Products Inc., Springfield, Mo.

1975

Frederick R. Chase *(Civil and Mineral)* is president of Rice Lake Contracting Corp. in White Bear Lake, Minn. **Michael B. Eckhardt** *(Mechanical)* is a project manager for Johnson Controls in Brooklyn Center, Minn. Eckhardt earned his M.B.A. degree from the College of St. Thomas in 1983. **Robert E. Erikson** *(Civil and Mineral)* is a specialist in natural gas liquids planning for Amoco Corporation in Chicago, Ill. **John J. Feigal** *(Computer Science; 1985 M.B.A.)* is a senior principal software engineer for NCR Network Products Division in St. Paul. **Stephen M. Holly** *(Chemistry; 1980 M.B.A.; Chemical, 1983 M.S.)* is a founder and treasurer of Sorgo Fuels and Chemicals, a research, development, and licensing firm in St. Louis Park, Minn. **Paul B. Melnychenko** *(Geology)* is a geologist and owner of St. Croix Exploration Company, an oil and gas exploration firm in Denver, Colo. Melnychenko earned his master's degree in geology from the University of Wisconsin—Milwaukee in 1978. **Ned W. Rhodes** *(Electrical)* is a founder and president of Software systems Group, a consulting firm in Arlington, Va. Rhodes earned his master's degree in computer science from George Washington University in 1978. **Richard Schwarz** *(Electrical)* is a communication systems engineer. Schwarz, who lives in New Brighton, Minn., was named a senior member of the Institute of Electrical and Electronics Engineers in 1988.

1976

Jack O. Bly *(Mechanical)* is a project manager for Michaels Engineering Inc. in La Crosse, Wis. **Vernon E. Lippert** *(Electrical)* is an electrical maintenance engineer for George A. Hormel Co. in Austin, Minn. **Thomas Swanson** *(Mechanical)* is a systems manager for 3M and is living in Forest Lake, Minn.

1977

Steven J. Albrechtsen *(Chemistry)* is a professor of physiology at the University of Wisconsin—Whitewater. He also operates a consulting firm, Steven J. Albrechtsen and Associates. Albrechtsen earned his Ph.D. degree in physiology and biophysics from Colorado State University in 1985. **Patricia A. Morrison Blum** *(Computer Science)* is a systems manager for AT&T in Aurora, Colo. **Eldon M. Gath** *(Geology)* is chief geologist for Leighton & Associates in Diamond Bar, Calif. **Bruce R. McClintick** *(Chemical)* is manager of process engineering for Dow Corning Corp. in Midland, Mich. McClintick earned his M.B.A. degree from Central Michigan University in 1986. **Jerrold J. Tell** *(Civil and Mineral)* is structural engineering manager for Wolf & Associates in St. Paul.

1978

Peter S. Gross *(Civil and Mineral; 1981 M.B.A.)* is president of Aeromix Systems Inc., a Minneapolis manufacturing firm he founded in 1987. **Mark C. Koenig***(Civil and Mineral)* is a customer service group manager for R. R. Donnelley & Sons in Dwight, Ill. Koenig earned his M.B.A. degree from the University of Iowa in 1982. **Todd B. Nippoldt** *(Mechanical)* is a physician for the Mayo Clinic in Rochester, Minn. Nippoldt earned his M.D. degree from Mayo Medical School in 1982. **Neil T. Schwanz** *(Civil and Mineral)* is a civil engineer for the U.S. Army Corps of Engineers in St. Paul. Schwanz was named the Society of American Military Engineers Young Engineer of the Year in 1984. **Wesley E. Sund** *(Chemical)* is a licensing specialist at the Phillips Petroleum Co. Research Center in Bartlesville, Okla.

1979

Eric D. Anderson *(Electrical)* is a software engineer for Control Systems Inc. in St. Paul. **Stephen J. Strauss** *(Chemistry; Chemical, 1981)* is a senior product engineer for 3M in St. Paul. Strauss was named to the Circle of Technical Excellence at 3M in 1987.

1980

Timothy S. Josephson *(Mechanical)* is a mathematics instructor for the Duluth School District. **Brian W. Maus** *(Electrical)* is a project engineer for FMC, Naval Systems Division in Minneapolis. **Karen F. Waggoner Straus** *(Computer Science)* is vice president of Mission Imports, a gifts and handicrafts importing firm she and her husband founded in Dallas, Texas. **Michael T. Zuroski** *(Electrical, 1990 M.S.)* is a senior research engineer for Nelson Industries Inc. in Stoughton, Wis.

1981

Robert F. Kiszewski *(Electrical)* is an electrical engineer and owner of ATI, a Superior, Wis., electrical engineering and control design firm. **Lesley E. Ott** *(Mechanical)* is a design engineering manager for TRW-Nelson Stud Welding in Elyria, Ohio. **John J. Viveiros** *(Geophysics; Geology, 1984)* is a development geophysicist for Chevron USA in Midland, Texas. Viveiros earned his master's degree in geophysics from the University of Utah in 1986.

1982

Maurice S. Aljadah *(Mechanical)* is a senior project engineer in the CIM/Technology Department at the General Motors Technical Center Advanced Engineering Staff in Warren, Mich. **Michael K. Anderson** *(Civil and Mineral)* is an environmental engineer for the Iowa Department of Natural Resources in Des Moines, Iowa. **John E. Canfield** *(Mechanical)* is a business consultant in quality and organizational development in Holland, Mich. **Minh Q. Nguyen** *(Electrical)* is an electronics engineer/data communications specialist at the Space and Naval Warfare Systems Command in Washing-

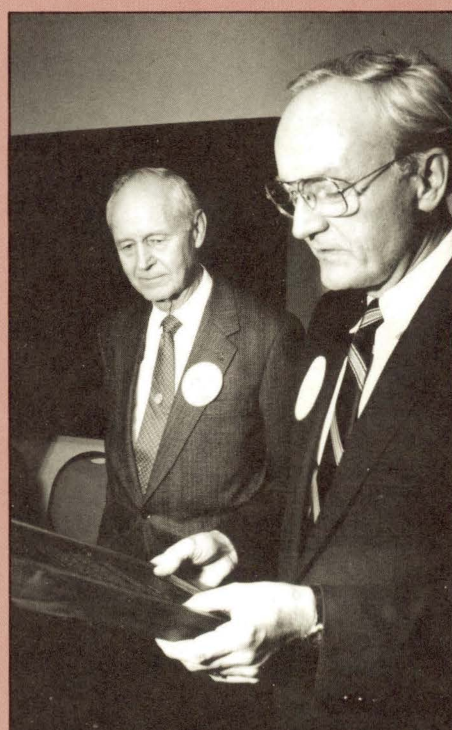
when a young woman he knew mentioned she had a friend who was majoring in home economics, Johnson called her up for a blind date. Mary Thomes turned out to be talented and bright. Valedictorian of her high school class, she was a good match for Johnson's quick, inquisitive mind. They were married shortly after Johnson graduated with distinction in 1939 and accepted a job offer with B. F. Goodrich Co. in Akron, Ohio.

For seven years, Johnson worked at Goodrich in raw material testing, plastic product research, and product development. In 1946, Charles Thomes, Johnson's father-in-law, asked Johnson to become a partner in Thomes' mayonnaise and canned food business. No thanks, replied Johnson, who loved his plastics research job. Thomes countered with an offer to start a plastics company in Minneapolis and Johnson accepted. Within six months of Johnson's return to Minneapolis, Mayon Plastics, named in honor of Thomes' business, began producing garden hose, which was in short supply following World War II.

Although business began slowly, by 1955 Mayon Plastics, with 10 employees, had prospered enough to move into its own building in Hopkins. Meanwhile, Johnson developed a formula for flexible surgical and food supply plastic tubing and landed a contract with University of Minnesota Hospitals. This soon led to an international trade that included Dr. Christian Barnard in South Africa.

Johnson often cites luck as a key ingredient to his success—along with a bit of motivation and hard work—but a long-time friend, Earl Mosiman, thinks organization plays a major role.

"Ray Johnson is the most organized and painstakingly careful person I know," Mosiman says. "He has records and statistics of everything that has happened to him and his wife over the last 49



Ray Johnson (left) and University of Minnesota President Nils Hasselmo.

years." Johnson's penchant for organization and attention to detail has landed him the unofficial title of group historian for their biking group, the Tweeweilers—a Dutch word for bicyclists.

If Johnson seems to tackle life full blast, the same can be said for the company he keeps. Over the last 10 years, the

Tweeweilers—26 seniors in their mid-60s to early-70s—have bicycled in Holland, France, California, and throughout Minnesota. Collectively, the Tweeweilers have had five hip replacements, four have heart conditions, two have had back surgery, three have knee problems, and two have had shoulder separations. What keeps them going is the inspiration they give each other and the belief that life is what you choose to make it.

"As long as I have the wherewithal, I'm going to use it," says Johnson. In addition to bicycling, Johnson's an avid golfer and competitive badminton player. With his left-over "wherewithal," Johnson is writing an autobiography. As one might guess, it is documented with painstaking care and well organized, being divided into four basic chapters on the mental, moral, physical, and financial aspects of his life. Johnson claims the book is for his own edification. Time will tell. For now, he's content documenting his good fortune and good times. It's just another job that needs to be done. I

By Trish Grafstrom

The creative spark

Sometimes the simplest of incidents can stimulate a lifetime of curiosity. As a child, Richard Jordan shorted a battery, creating a burst of sparks. From then on, Jordan recalls, "I was fascinated with anything having to do with electrical or mechanical devices. I never had any problems deciding what to be—I always wanted to be an engineer."

Jordan's single-mindedness served him well as he embarked on a career that eventually resulted in a measure of fame and recognition not only for Jordan, but for the University of Minnesota as well. In 1931, he became the first undergraduate to earn a degree in aeronautical engineering from the Institute of Technology. In 1933, he earned his master's degree in mechanical engineering and took a job with American Radiator. Three years later, the University of Tulsa recruited him to teach petroleum engineering, and his career in academia was launched. After working on a summer research contract at the University of Minnesota during 1937, Jordan decided to stay at the University and continue his graduate studies. In 1940, he received the first Ph.D. in mechanical engineering awarded by IT.

After his doctoral work, Jordan joined the faculty of the IT mechanical engineering department. During the next 40-plus years, Jordan had a tremendous impact on the department, helping to improve its reputation from that of an "also-ran" to that of an outstanding department. For 27 of those years, he served as head of the department. He also served as associate dean of IT for more than seven years.

As a professor, Jordan valued the role of creativity in engineering and spent a good deal of time thinking about how to encourage it among his students. He tried to inculcate creativity in undergraduate students by giving them problems that have never before been solved. "That way, you avoid the tedious and rote aspects of solving historical problems that have well-known solutions," he says. Jordan and professor Gil Taylor started a course titled "Creativity in Design," which evolved into the department's primary design course.

Through the years, Jordan received many professional accolades and honors. His research studies in refrigeration, energy conservation, and solar energy are widely acknowledged. He was elected to the National Academy of Engineering. In 1979, he received the University of Minnesota Outstanding Achievement Award. In spite of these and numerous other professional honors,

ton, D.C. **Gregory S. Paulson** *(Civil and Mineral)* is the Pine County Engineer and lives in Pine City, Minn. **James M. Sellner** *(Civil and Mineral; Geological Engineering, 1985 M.S.)* is a senior mining engineer for the Minnesota Department of Natural Resources in Hibbing, Minn.

1983

Dennis P. LaCasse *(Electrical)* is an electrical/test engineer for Control Data Corp. in Arden Hills, Minn. **Timothy R. Newman** *(Aerospace)* is a captain and satellite operations officer in the U.S. Air Force in Colorado Springs, Colo. He earned his master's degree in aerospace engineering from Northrop University in 1988. **Douglas J. Peterson** *(Chemical; 1985 M.B.A.)* is a systems analyst for Ford Motor Company in Dearborn, Mich. **Mitchell A. Wayne** *(Mechanical)* is a senior mechanical engineer for Consolidated Papers Inc. in Wisconsin Rapids, Wis.

1984

John M. Boylan *(Agricultural)* is an account representative for Protection Mutual Insurance in Brookfield, Wis. **Bruce A. Brandeland** *(Electrical)* is a development engineer for Cardiac Pacemakers Inc. in St. Paul. **Philip A. Lehrke** *(Aerospace)* is a senior engineer in configuration/design for McDonnell Douglas Corp. in St. Louis, Mo. **Dennis T. Schult** *(Physics)* is an engineer for The Boeing Company in Seattle, Wash. He earned his master's degree in physics from the University of Washington in 1988.

1985

Mark D. Elpers *(Electrical)* is a design engineer for ADC Telecommunications in Minnetonka, Minn. **Kevin J. Hyde** *(Mechanical)* is a systems engineer for PRC Reston in Virginia. Hyde earned his M.B.A. degree from George Washington University in 1987. **Keith W. Jacobson** *(Civil and Mineral)* is a branch engineer for VSL Corporation in Burnsville, Minn. He earned his master's degree in civil engineering from Cornell University in 1986. **Constantine S. Papageorgiou** *(Chemistry)* is a doctoral candidate at San Diego State University. He earned his master's degree in chemistry from the University of California—Santa Barbara in 1987. **Gary J. Swanson** *(Electrical)* is a component and circuit design test engineer for Cray Research Inc. in Chippewa Falls, Wis. **Vera J. Trueblood** *(Mechanical)* is a design and development engineer for Chrysler Corporation in Madison Heights, Mich. Trueblood, who is working toward an M.B.A. degree at the University of Michigan, received the Chairman's Award from Chrysler Corporation.

1986

Mark D. Bjelland *(Civil and Mineral)* is an environmental engineer for Barr Engineering Co. in Bloomington, Minn. Bjelland earned his master's degree in civil engineering from the University of Washington in 1989. **Rob G. Curtis** *(Electrical)* is an applied systems engineer for Motorola GSS in Arlington Heights, Ill. **Maryanne E. Kelly-Sonnek** *(Civil and Mineral)* is a graduate engineer II for the Minnesota Department of Transportation in St. Paul. **Jennifer A. Shimota** *(Mechanical)* is a product design engineer for UFE Inc. in Stillwater, Minn. Shimota received her master's degree in mechanical engineering from the University of Michigan at Dearborn in 1988.

1987

Gregory L. Hasse *(Agricultural)* is a product engineer for Condux International in Mankato, Minn. **Thomas L. Johnson** *(Computer Science)* is a programmer/analyst for West Publishing Co. in St. Paul. **John D. Norton** *(Chemical)* is a graduate student and research assistant in chemical engineering and materials science at the University of Minnesota. Norton received an IBM Graduate School Fellowship in 1990.

1988

Alan T. Forsberg *(Civil and Mineral, M.S.)* is a county engineer for Blue Earth County in Mankato, Minn. **David A. McNeil** *(Chemical)* is an associate engineer for Shell Oil Co. in Houston, Texas. **Keith T. Richter** *(Mathematics)* is a manager for Mann Companies Inc. in Waukegan, Ill. **Steven J. Snell** *(Mechanical)* is a manufacturing engineer for UFE Inc. in Dresser, Wis. **Valts E. Treibergs** *(Mechanical)* is a mechanical engineer for E. F. Johnson Co. in Waseca, Minn.

1989

Tracy S. Lemke *(Electrical)* is an electrical engineer for The Boeing Company in Seattle. **Darrin S. O'Brien** *(Aerospace)* is a development engineer for The Trane Company in Tyler, Texas.

1990

David J. Andrews *(Mechanical)* is a process engineer for 3M in St. Paul. **Paul J. Killian** *(Chemistry)* is a development engineer for RTP Company in Winona, Minn. **James E. Studenski** *(Civil and Mineral)* is a civil engineer for TKDA in St. Paul. I

however, Jordan is especially proud of the work he did to recruit outstanding faculty members such as Daniel Yung, Ernst Eckert, Perry Blackshear, and Ben Liu.

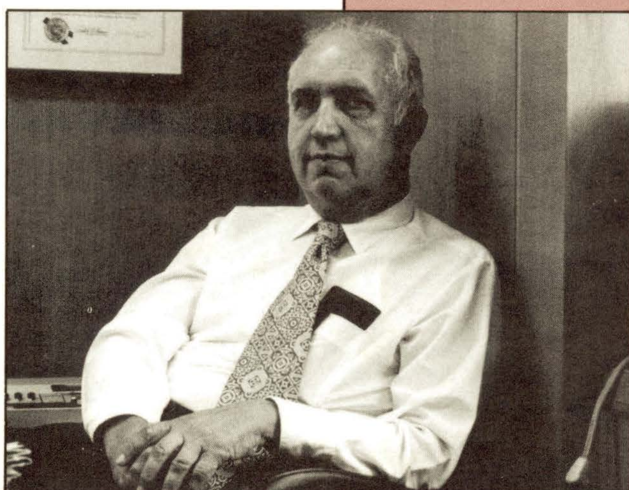
"I worked hard to form a matrix that would support the outstanding activities of the faculty and one in which they would enjoy working," Jordan says.

Jordan retired as a full-time professor in 1976, but continued to serve half-time as associate dean of IT until 1983. He also worked for Control Data Corporation and did private consulting. In 1986, he retired to Rio Verde, Arizona. Now, his days are pretty full with golf, bridge, travel, and some consulting work, but he still finds time to keep a finger on the pulse of IT.

"There are a number of wonderful things about IT," Jordan says. "Unlike other great research universities, IT does not require every faculty member to raise research funds. And the deans put a high amount of responsibility on department heads."

To IT undergraduates who are considering the life of a professor, Jordan advises: "You need an internal desire to teach and work with students and enjoy doing it. It is not the path to take if you are primarily motivated by money. You need to be more interested in ideas, and you need an ability to work with people and understand the problems of students."

And finally, Jordan advises professors to be honest with their students and give them "a good deal of freedom." After all, it is the freedom to experiment that sparks creativity. I



Richard Jordan

News About You

Name

Address

City, State

Graduation Year/Degree/Department

Job

Employer/Location

Other News

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DEATHS

Ralph E. Allison *(Electrical 1930)* of Hilo, Hawaii, in October 1990. A more detailed notice will be published in our next issue.

Elmer S. Dinesen *(Mechanical 1941),* age 71, of Minneapolis. Dinesen worked at the Unisys Corp. Roseville plant for more than 20 years before retiring at age 65. Dinesen was very active in the Boy Scouts of America (BSA). He first began working with scouts more than 40 years ago when he became scoutmaster at Richfield Lutheran Church. He became a unit coordinator in the Miniwicota District of the Viking Council of BSA and worked with adult leaders. He received a merit award from the Miniwicota District three years ago. Dinesen was also past president of the congregation at Mount Zion Lutheran Church in Minneapolis and a member of the Minneapolis Engineers Club.

Arndt J. Duvall, Jr. *(Civil and Mineral 1925),* 86, of White Bear Lake on September 14, 1990. Duvall, who received the University of Minnesota Outstanding Achievement Award in 1973, was a retired engineer and former president of Toltz, King, Duvall and Anderson, a St. Paul engineering and architectural firm. Although born in Stillwater, Duvall grew up in St. Paul and graduated from Central High School in 1921. While attending the University, Duvall was a member of Tau Beta Pi, an engineering honors society, and captain of the tennis team. After graduation, Duvall worked for the Missouri State Highway and Bridge Department in Jefferson City, Mo., for a year and then returned to St. Paul in 1926 and worked for what was then Toltz, King and Day. Except for a brief interlude between 1934 and 1939 when Duvall worked for the Minneapolis-St. Paul Sanitary District, he remained with the Toltz firm until he retired in 1982, becoming its director in 1940 and serving as its president from 1959 to 1979. Duvall was past president of the Central States Water Pollution Control Association, the northwest section of the American Society of Civil Engineers, and the St. Paul Breakfast Club.

Margaret Buckley Laska of Shalimar, Fla., on September 21, 1990. Laska was employed in Dean Ora Leland's office during the late 1920s and early 1930s. Her husband, Frank, received his bachelor's degree in civil engineering from IT in 1931.

James C. Olson *(Civil and Mineral 1961),* 52, of Plymouth, Minn. Olson worked for Bonestroo, Rosene, Anderlik & Associates Inc. in Roseville for 30 years. Olson designed water, sewer, and street projects for several Minnesota cities. He did consulting work in Chaska, Plymouth, Maple Grove, Mapleton, and Redwood Falls. Olson was a native of Clarkfield, Minn. He was very active in youth athletic programs and was a member of the Plymouth Civic League.

Walter L. Thomte *(Mineral Resources 1935),* 82, of Pine River, Minn., on January 17, 1990. Thomte began his career working for the Minnesota Highway Department as a design engineer before moving into mining with Pickands Mather Mining Co. in Hibbing in 1941. In 1946, he became chief engineer at the Danube Mine in Bovey and then superintendent in 1952. Thomte was made superintendent of the Western Range Area in 1958 and superintendent of the Embarrass and Corsica Mines in 1959. In 1961, he became superintendent of mines and railroads at the Erie Mining Co. Taconite Plant in Hoyt Lakes. From 1963 until he retired in 1968, Thomte served as administrative assistant to the works manager. Thomte wrote several articles on mining and was a life member of the Engineers Club of Northern Minnesota. I

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