Summer 1992

ITEMS

UNIVERSITY OF MINNESOTA
INSTITUTE OF TECHNOLOGY

Giants in Lilliput

EE Professors Dennis Polla and Stephen Chou make BIG progress with unbelievably small electronic devices.

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and
A Salute to IT Supporters

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ITEMS

University of Minnesota
Institute of Technology

Summer 1992

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 IT Dean's Office, Institute of Technology, 107 Walter Library, 117 Pleasant St. S.E., University of Minnesota, Minneapolis, MN 55455, or call Jon Meister, 612/626-1804. *ITEMS* welcomes letters and ideas from all readers.

About the Cover: As rising stars in their respective fields, Electrical Engineering Professors Dennis Polla (micro-machines) and Stephen Chou (nanoscale fabrication) are always on the go. In early March, however, we managed to get them both to stand still for a few minutes for this photograph, taken in Polla's lab. *Photo by Rob Levine.*

NEWS

IT Teams Up with Girl Scouts

In an effort to build interest in math and science among teenage girls, the Institute of Technology held an IT Science Opportunities Day for Girl Scouts on April 4, 1992. Co-sponsored by IT and the Greater Minneapolis Girl Scouts Council, the event brought more than one hundred Girl Scouts and troop leaders to the East Bank campus to experience science and engineering in a university setting.

The program targeted 13- and 14-year-old girls based on studies that show this to be a critical age for young women in making long-term decisions about math and science.

To provide the scouts with necessary role models, many of the volunteer guides and presenters were women undergraduate students, graduate students, and professors at IT. The guides and presenters were available throughout the day to answer questions on the university, their particular disciplines, and how they came to choose science or engineering for their careers.

The participants were divided into groups and, following opening remarks by Associate Dean Sally Gregory Kohlstedt who initiated the event, they rotated through a series of demonstrations and hands-on activities offered by the departments of astronomy, chemistry, civil and mineral engineering, and geology. A mid-afternoon snack was provided at the Bell Museum of Natural History, where the participants had the opportunity to view numerous exhibits.

According to Kohlstedt, IT will continue to pursue opportunities to inform young women of the many career options available in math and science. ■

Photo by Patrick O'Leary

More than 100 Girl Scouts participated in IT Science Opportunities Day, an event designed to make young women aware of the many career opportunities in math and science.

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Additional Companies Founded by IT Alumni

(Not Listed in the Special Issue)

IT 400 Now 550

Continued research since the publication of the special "IT 400" issue of *ITEMS* has swelled the IT 400 to 550 companies founded by graduates of the Institute of Technology.

Worldwide, these firms generate $15 billion in annual sales and employ 130,000 people. Two-thirds of the firms are Minnesota-based. The Minnesota firms generate $10.3 billion in annual sales and employ 85,000 people, 52,000 of whom are located within the state.

ITEMS will continue to update these numbers as new information is collected. The following is a list of companies founded by IT graduates not included in earlier publications. **I**

Corporation	*IT Founder*
Advanced Research Corporation	Matthew Dugas 79/Physics
Agro-K Company	Joseph Shuster 55/ChemE
Ampro Applied Motion Products	Doug Nagle 73/MATH
Blue Water Science	Steven R. McComas 83/CE
BMT, Inc.	William Turner 47/ME
BRW	Edward C. Bather 48/CE
Bulk Molding Compounds, Inc.	James E. Cabak 60/ME
By-West Engineering	David Westby 70/EE
Cabak Randall Jasper Griffiths Assoc.	Michael R. Cabak 55/CE
Cain Ouse Associates, Inc.	Jay J. Cain 72/EE
Card Systems Test Labs	Clark E. Johnson, Jr. 50/Phy
Card Systems Testing Labs	Clark Johnson '50 PH
Carey Electronics	Reece Carey,Sr. '32
Carlson Associates Int'l., Inc.	M. Edward Carlson 45/EE
Carr Associates	William R. Carr 51/CE
Carson, Lundin & Thorson, PC	Robert L. Thorson, 53/Arch
Cartwright Consulting Co.	Peter Cartwright 61/ChemE
Cascade Medical	Burt Walter 68/Chem
CleanSoils Equipment Inc.	James K. Poucher 77/CE
CleanSoils Inc.	James K. Poucher 77/CE
Cogent Computing Company, Inc.	Robin Steele 84/CS
Concrete Forms Engineers, Inc.	Robert L. Youngdahl 58/ME
Cyro-Diffusion	Joseph Shuster 55/ChemE
Datacard Corporation	Richard Hencley /ME
Delbert F. Jurgensen Associates	Delbert Jurgensen 31/ChemE
Design Associates	Cardell E. Miller 55/ME
DHC Enterprises, Inc.	Don Craighead 57/ME
Dotray & Associates, Inc.	K. Paul Dotray 55/ME
Eden Systems, Inc.	Edward A. Stafford 62/ME
Electronic Controls, Inc.	Al Balmer 76/EE
Ellison, Pihlstrom & Ayres Inc.	Robert J. Ellison 37/CE
Emerson EMC (formerly Kiowa Company)	Tim Erhart 71/EE, Doug Nagle 73/MATH

Corporation	*IT Founder*
ExtraTech Corporation (Fillmore Systems)	Robert L. Fillmore 46/EE
Factory Systems Engineering Inc.	Russ Foster 69/ME
Flight Engineering, Inc.	Timothy J. Haney 85/AE
Gagnon & Associates	Eugene Gagnon 56/IndEng
General Motion Corp.	Jack Levi 76/ME
GLC Capital (Griffith, Levi Capital)	Jack Levi 76/ME
Great Plains Supply, Inc.	Michael R. Wigley 78/CE
Group Dekko International	Chester E. Dekko 45/ME
High Iron Travel Corp.	Clark Johnson '50 PH
Holewa Management Consulting Group	Andrew J. Holewa 72/EE
Hope International Family Services	Theodore Trampe 61/Chem.
Hydro-Bikes, Inc.	Raymond J. Buresch 63/AEM, Phillip E. Schlangen 90/ME, Dean A. Dversdall 58/AEM
Independent Consulting Engineers	Bradford A. Lemberg 59/CE
Integrated Measurement Systems, Inc.	Wilfred B. Baril 76/EE
International Cryobiological Services	Joseph Shuster 55/ChemE
Interpoint Corporation	Phillip C. Linwick 53/ME
Kleinschmidt, Inc.	Harry S. Gaples 57/Math
Knightronix, Inc.	Arnold W. Knight 62/EE
Larson Engineering of Minnesota	Wayne C. Larson 60/CE
Lewis Engineering Company	Gordon C. Lewis 51/ME
Loeffel-Engstrand Company	Robert L. Loeffel 51/CE
McGrann Shea Franzen Carnival Straughn & Lamb	Robert O. Straughn 65/CE
McLinn, Dale and Associates	James A. McLinn 74/Phy, Everett H. Dale 49/EE
Membran	Eugene E. Erickson 44/ChE
Mesabi Control Engineering Ltd.	Robert Lange 60/EE
Micro-Design Inc. (American Micro-System)	Donald C. Burkness 48/ME
Mikros Engineering, Inc.	James E. Talmage 60/ME
Minnesota Technical Advisory Bureau Inc.	William T. Sutherland 70/EE
Nelson-Rudie and Associates	Dennis A. Nelson 65/CE, Scott F. Rudie 69/ME
Nooter/Eriksen Cogeneration Systems	Vernon L. Eriksen 65/ME
Quality Motion Control Co.	Joseph Shuster 55/ChemE
Rastech Inc.	Clark Johnson '50 PH
Ring Construction Corp.	Harold F. Ring 44/CE
Ross-Hime Designs	Mark Rosheim/undergrad ME
Rust Architects	William E. Rust 74/Arch
Samsung Semiconductor	Sang Joon Lee 72/EE
Saratoga Venture Finance	John L. Nesheim 65/AE
Schlangen Drives, Inc.	Phillip E. Schlangen 90/ME
Simons-Conkey Inc.	David Conkey 47/ME
St. Paul Growth Ventures	Spence G. Morley 82/EE
Strgar-Roscoe-Fausch, Inc.	Robert B. Roscoe 67/CE, Peter A. Fausch 64/CE
Tamarack Habilitation Technologies	J. Martin Carlson 63/AE
Technical Marketing Co., Inc.	Gilbert Overson 65/ChE
Telident	Richard Hencley /ME
The Works-A Technology Discovery Center	Rebbeca Schatz 86/CSci
Thermosystems	Robert E. Keppel 56/AE
Torkelson and Associates	Robert E. Keppel 56/AE
Van Bergen and Markson, Inc.	Paul A. Markson 31/EE
Vericom Corp.	Jack Levi 76/ME
Walvatne Industrial Services	Erwin Walvatne 50/EE
Wingfield Performance Engineering	Jeffrey R. Wingfield 78/ME, Ellen Wingfield 80/ME
Yorktown Executive Suites	Edward C. Bather 48/CE
Yorktown Office Court	Edward C. Bather 48/CE

Inventing Tomorrow Sponsors - 1992

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Kenneth and Judy Dayton
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Ingwald Kvitrud Trust
Arthur R. (60/AE) and Emma Jean Kydd

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Barr Engineering, Founded by
Douglas W. Barr (48/CE)
Donald H. Craighead (57/ME)
(Craighead Family Fund of the
St. Paul Foundation)
Richard P. (49/EE) and Marguerite Daly
Ruth and Bruce Dayton
Provost Ettore F. Infante
Interactive Network Technologies
Founded by William Kamp (75/MATH)
Frederick W. Lang (49/EE)
John W. Larson
Edward E. Mueller (41/ME)
Mildred A. Reeves
Loren E. Swanson (44/EE)
Gerald I. Williams (50/EE)

Friends (up to $1,500)

William A. Crosley (49/AE)
Frank C. Mullaney (43/EE)
Wendell L. Hung (71/AE
Marilyn and Gene Scapanski

Enterprise Forum is Highlight of Jam-packed IT Week

More than 700 alumni, students, and friends of the Institute of Technology participated in IT's "Enterprise Forum," the focal point of IT Week held May 4-8, 1992.

The first in a series of special conferences planned for future IT Week activities, the Enterprise Forum on May 7 gave participants an opportunity to learn from the collective wisdom and experience of more than 80 successful IT entrepreneurs who served as speakers and presenters for the program and a companion conference, The Quality Imperative, held May 8.

The Enterprise Forum consisted of 20 one-hour-and-15-minute sessions divided into five tracks:

- Career/Venture Planning
- Lifelong Skills for Achieving Excellence
- Ropes to Skip and Ropes to Know: Insights Gained from Experience
- Products and Markets
- Business Sectors of Opportunity.

Each session was led by a panel of distinguished and successful IT entrepreneurs. Judging from participant response, the entrepreneurs were every bit as successful in sharing advice as they were in their respective businesses.

"It was an excellent opportunity to look into the future," says IT student Kelly Bushlack. "It generated excitement for your career and future opportunities."

"I was most impressed by the program," says Bob Linsmayer (44/ME). "A similar program should be held each year for the benefit of all."

The excitement was not limited to the participants, however. Even the panelists were a bit overwhelmed by the enthusiastic response of participants.

"I couldn't stop answering questions from the audience at sessions, or even after the sessions were over," says Julius M. Rivkin (47/EE), an Enterprise Forum panelist. "They were really interested in what we had to say."

Those unable to attend can still reap the rewards of the conferences. Each session has been captured on both video and audio tapes. (For more information on how to purchase tapes, refer to advertisement on page 37.)

Other IT Week activities caught the attention of returning alums and students as well. Some 45 members of the IT Class of 1942 gathered to celebrate their 50th anniversary reunion. Traditional IT Week activities--such as the Tech Fair, pie throws, and the IT Olympics--were

Forum
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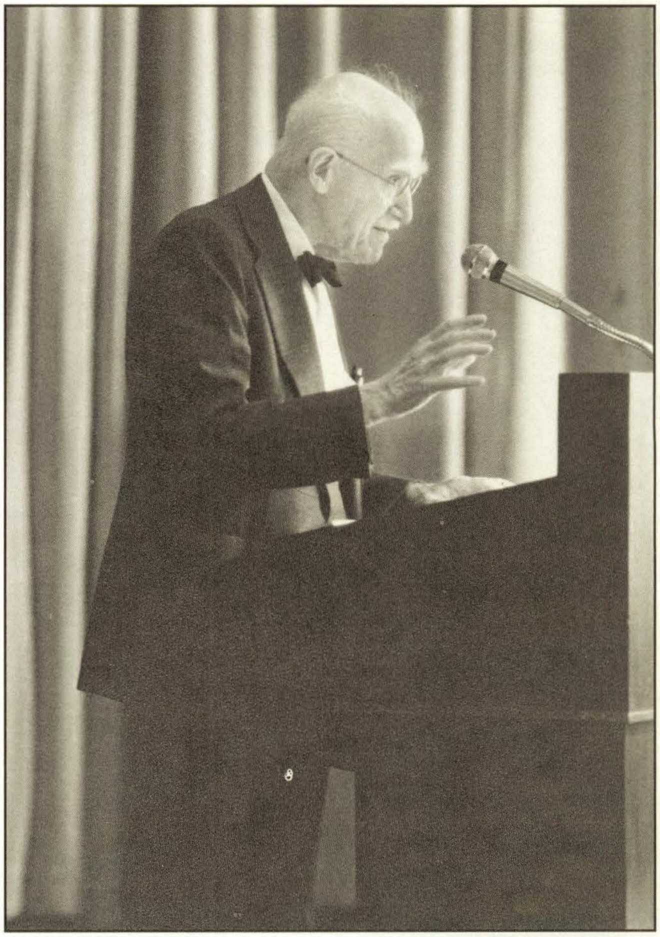
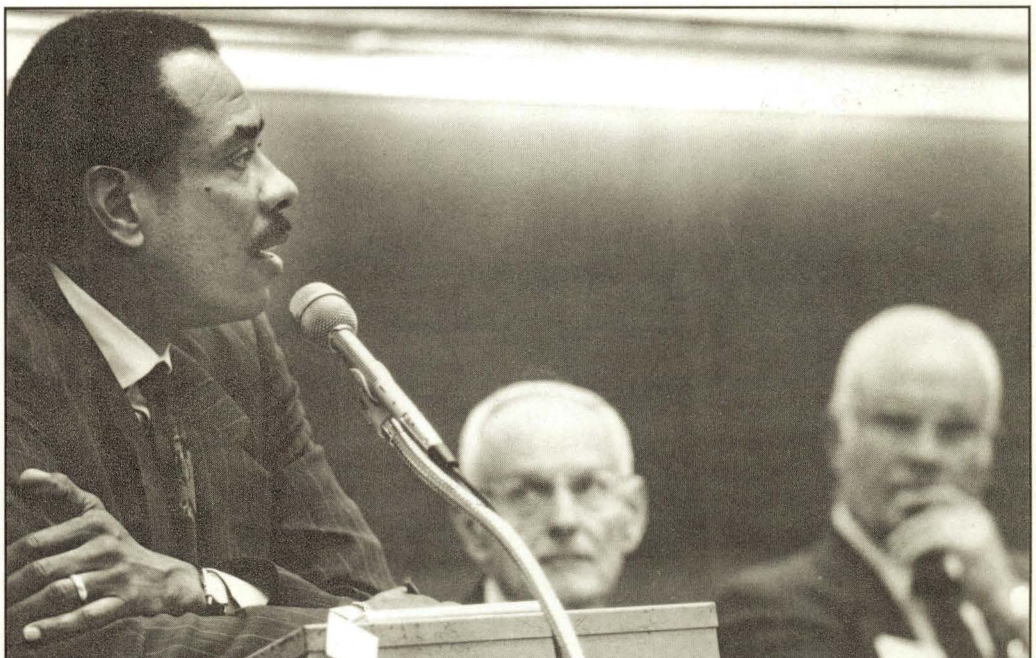


Joseph M. Juran (24/EE) presented the keynote address at the May 7 luncheon.



Fredrick M. Green (67/ME), Daryl G. Mitton (44/ChemE), and Lester C. Krogh (52/Chem), presenters for Enterprise Forum Track C3: Corporate Entrepreneurship.

Enterprise Forum
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organized by the student organization, Plumb Bob.

Joseph Juran (24/EE), chair emeritus of the Juran Institute and a renown expert on total quality management, gave the keynote address at the annual Science and Technology Day Banquet on May 8. Juran received a standing ovation following his speech. The 101 top entrepreneurs among IT alumni were presented with a plaque honoring their achievements. Along with his address, Juran couldn't resist commenting on the successful conferences.

"May I congratulate the organizers of this day," he said. "These activities, to my knowledge, are unprecedented. The concept is brilliant. It ought to be repeated over and over again because of the inspiration it gives to people, young and old."

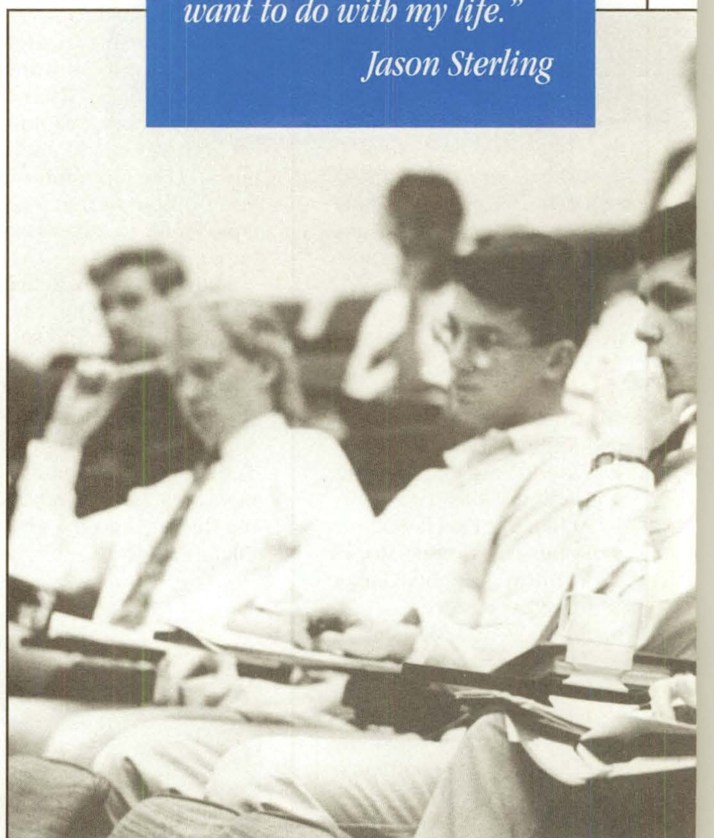
Next year's IT Week will focus on corporate leadership, featuring a conference on May 7 presented by IT alumni who have become CEOs and upper-level managers for some of America's most successful companies. For more information, contact Jon Meister at 612/626-1804.

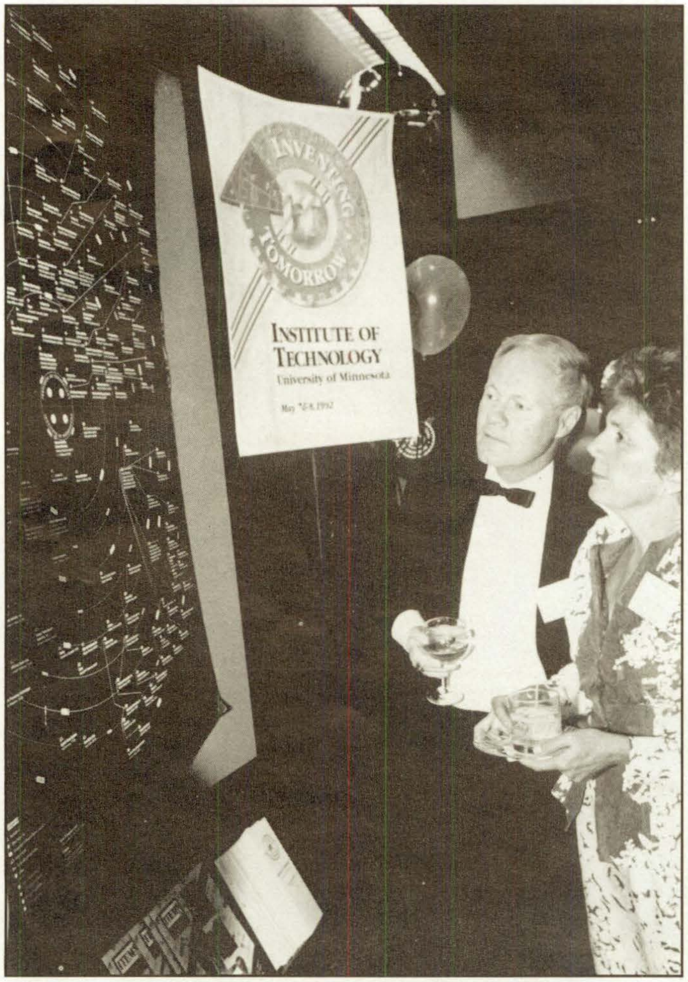
Two Thumbs Up

Among the many participants in the Enterprise Forum was a group of IT students from a freshman physics class. Their comments capture the essence of participant reaction to the sessions.

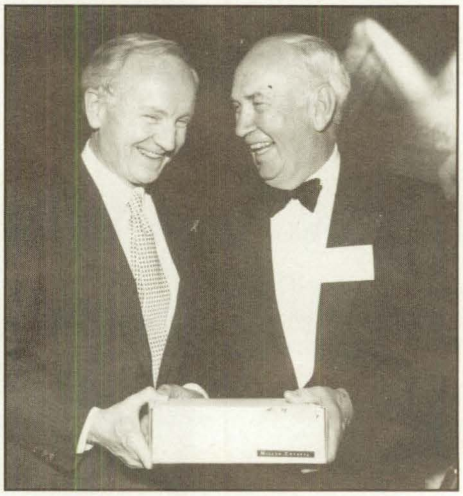
"In the two sessions I attended, I learned a lot about myself and what I want to do with my life."

Jason Sterling





Lee W. Johnson (57/ME) and Betty Johnson took time out to examine the display: "IT-Founded Companies 1891-1991."



University President Nils Hasselmo presented Richard J. Hanschen (45/EE) with a plaque honoring him as one of the top 101 IT entrepreneurs.

Robin L. Steele (83/CS), William P. Kamp (75/Math), John L. Borowicz (80/CS), Richard P. Daly (49/EE), and Kristine M. Black (75/Phys), presenters for Track E1: Computer Software and Professional Services: Current Environment and Future Challenges.

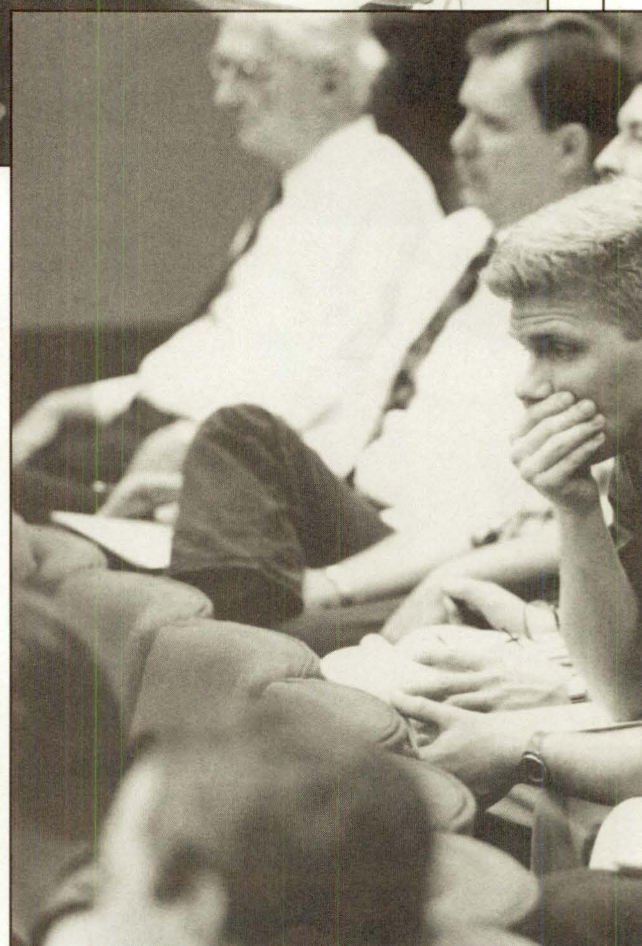
H. David Dalquist (42/ChemE), a presenter for Track D3: Innovation and Product Design, discussed successful products developed by the company he founded, Northland Aluminum Products.

"It was fun to see how IT graduates had prospered and succeeded in the engineering and business world of today."

Jennifer Difflay

Lloyd G. Cherne (50/EE) and James Meullner (65/ME), presenters for Enterprise Forum Track D1: Two New Products, Two New Markets.

Forum participants packed the Great Hall in Coffman Union for a luncheon and keynote address by Juran on May 7.



Bryan J. Beaulieu (72/ME) and Erwin Tomash (43/EE), presenters at Enterprise Forum Track A2: The Better Mousetrap Myth: Always Begin with a Market Opportunity.

Lester C. Krogh (52/Chem), Donald H. Craighead (57/ME), and Kristine M. Black (75/Phys) compared notes before the sessions got underway.

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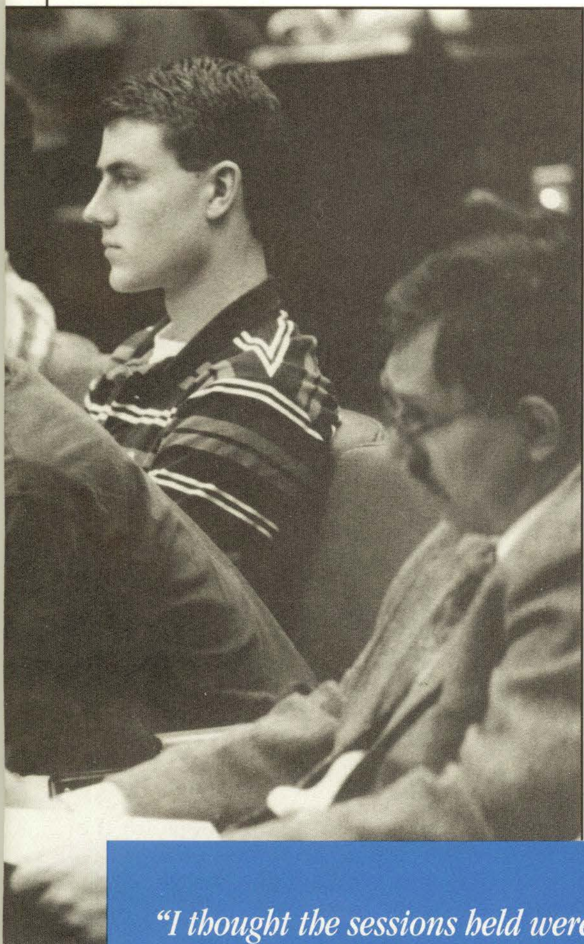
"I'm saving my notes so I will always have them for future reference, no matter what I choose as a career or major."

Chad Lewandowski



"I thought the sessions held were very informative and helpful. During the long process of earning a degree, it's easy to lose sight of what schooling is for--having a career. It was good to see IT graduates who have been successful and realize that all the work put into school will pay off some day."

Eric Engebretsen

NEWS

President Bush Honors Juran

In a ceremony at the White House Rose Garden on June 23, 1992, President George Bush presented Joseph M. Juran (24/EE) with the National Medal of Technology. Juran, chair emeritus of the Juran Institute and keynote speaker at this year's IT Week banquet (see article on page 5) was honored for his lifelong work in the management of quality.

President Bush cited Juran "for his lifetime work of providing the key principles and methods by which enterprises manage the quality of their products and processes, enhancing their ability to compete in the global marketplace."

The National Medal of Technology is presented annually by the president to individuals and companies for their outstanding contributions to improving the well-being of the United States, either through the development or commercialization of technology or for their contributions to the establishment of a technically trained work force. I

President Bush and Barbara Hackman Franklin, Secretary of Commerce, present Joseph M. Juran with the National Medal of Technology.

Credit Where Credit is Due

In "The Countdown to Zero Emission" (*ITEMS*, Winter 1992), it seems we credited Mechanical Engineering Professor Edward H. Fletcher with the design of the solar furnace atop the Mechanical Engineering Building. Professor Fletcher set us--and the record--straight.

"Although the furnace was created by many students, both graduate and undergraduate, and I even drew some sketches and pounded some nails myself," Fletcher wrote us, "one former student, Richard B. Diver, who is continuing to do important solar work at Sandia National Laboratory, stands out as the chief architect and builder of the furnace. In testimony to that, the cornerstone plaque on the 'instrument case' we built to protect the concentrator-receiver from the elements reads, 'Diver Hall, MCMLXXXI.'" I

VIEWPOINT

The Inside Word

Gordon Campbell (Physics), president, chair, and CEO of Chips and Technologies, Inc.

Gordon Campbell founded Chips and Technologies, Inc. in late 1984. In just seven years, Chips has become a leader in the electronics industry, particularly in the area of microprocessors and related hardware. Today, Chips employs 700 people and has exceeded $200 million in annual sales for three years in a row, nearing $300 million in 1990.

Campbell has honed a keen understanding of the electronics marketplace. His insights have been further enlightened through his efforts to compile a history of the semiconductor industry. ITEMS publisher, John Larson, interviewed Campbell recently at his offices in San Jose, Calif. During the interview, Campbell shared his thoughts on a wide range of topics, including the impact of cheaper, more portable and powerful PCs, and the race to remain competitive with the Japanese.

Q The semiconductor industry is infamous for the speed with which new technologies emerge. What has Chips and Technologies developed recently to remain among the industry leaders?

One of the most exciting developments at Chips and Technologies is our new PC/CHIP™. This is the first time anybody has put an entire PC architecture on one chip. It includes the processor, all the logic, the graphics control, the communications, and a whole new concept that we call "SuperState"™. SuperState is a layer resident between the central processing unit and the rest of the system and can be programmed to provide advanced power management techniques for notebook and palm-top computers.

We used an XT architecture, but it has the power of an AT in terms of processing. It turns out three million instructions per second (mips) at full clock speed.

PC/CHIP will enable manufacturers to put the power of a desktop computer into a one- to two-pound notebook computer.

When will these machines hit the market and what will they cost?

They should be fairly prevalent by the end of this year. With this new chip, manufacturers can make a variety of very simple systems. At the low end, there will be notebook computers with reflective screens and relatively cheap memory and keyboards at a price probably in the $300 to $500 range. There will also be slightly more elegant products that include a much better keyboard, back-lit screen, and a hard drive for under $1,000.

These products, which will run any PC-compatible software, should have a strong market in education. Before long, kids will be carrying computers to school just like books.

Do you view this as a revolutionary development?

Yes, particularly in terms of cost. When notebook computers came out a few years ago, they were $3,000 to $5,000, depending upon their capabilities. Although we now have notebooks in the $1,000 range, you don't see anything at $500. I think the volume sales for this particular product are going to be in the sub-$500 range.

What are some of the other new areas you're exploring at Chips and Technologies?

We've also developed a group of 386- and 387-compatible processors that offer the highest performance in the industry. They operate at the same clock speed as Intel, but are 50 percent faster in performance. The SuperState feature, which I mentioned earlier, provides better power management, giving you longer battery life in notebooks.

It also gives manufacturers the ability to build desktop machines that "go to sleep." Right now, all desktop machines can be either on or off. With SuperState, we have the ability to put them in what we call the aware mode. It turns the monitor and hard drive off and almost all of the logic, but the processor is still "aware." It dissipates almost no power. If a message comes in on a network or a fax or voice mail, however, the processor comes up, determines what part of the architecture to turn on, receives the message, stores it, and goes back to the aware mode.

In a large company, with 500 to 1,000 PCs running nonstop, there are high maintenance bills and a lot of power is wasted. SuperState can reduce those costs.

Where do ideas like this come from? Do you start by trying to determine what consumers want?

Sometimes the market leads you by what it wants, and sometimes you have to lead the market with new ideas. With SuperState, I think we're leading the market.

We looked at the PC market from a portable and a desktop perspective and asked ourselves, "What would we really like?" We put together a list of the features and then asked ourselves how we could accomplish them. There was a raging six-month debate that went on in house about whether we should make a super high-performance chip or a low-power, high-performance chip. The designer of the chip and I found ourselves in a parking lot in Illinois one day talking to a customer who came down very hard on the low power side and that settled the debate.

It's wonderful to go out and find technical problems to solve, but if you don't have a market associated with it, you can't afford to do that for very long. On the other hand, we've seen people start companies without a good technical foundation for their products and that's just about as bad. Typically, the most successful companies have come from somewhere in the middle--where there's a nice balance between implementation of technology and understanding of the market.

There's a lot of concern in business these days about remaining competitive with the Japanese. How is higher education in the U.S. affecting our competitive advantage?

We have an amazing influx of Asians into our colleges. In the 1980s that worked because they came here, got an education, and stayed. Now, they're getting an education and going home because there's more money in Taiwan than there is here. Or worse yet, they're getting the education, going into our various industries to learn the industry, and then going home. We need to find ways to attract more Americans into getting advanced degrees. I think the pay is good for engineering graduates, but I don't see the same emphasis on engineering that used to be there when I went to school.

How do we stack up against the Japanese and other contenders in the international electronics market?

Let's back up a minute. First of all, the American electronics industry is the most creative and dynamic American industrial sector. It has incredible potential. Revenues flowing from electronics products nearly equal the size of the steel, automobile, and aerospace industries combined. We also employ nearly one million more Americans than all those industries combined. By the end of the millennium, the American electronics industry will be by far the largest single industrial segment of the American economy.

At one time, we held the lead in the world marketplace in most product categories. In 1980, U.S. companies shipped $3.1 billion worth of integrated circuits while the Japanese shipped $1.2 billion. In the market for MOS memory, American suppliers held 74 percent of the market; in microprocessors, 75 percent; in simple logic devices, 56 percent. Today, the Japanese have captured the lead in all of these product areas--except microprocessors, and the gap has narrowed there.

In the past, America was a great developer of intellectual property (patents and software copyrights, for example), and we probably didn't guard it as well as we should have. A number of discussions are now going on internationally on how to stop the Chinese, the Taiwanese, and other people from infringing on our intellectual property.

The American electronics industry is the most creative and dynamic industrial sector. It has incredible potential.

America has a competitive advantage in the area of intellectual property, but the Japanese, the Koreans, and, to a lesser degree, the Taiwanese are beginning to build their portfolios, too. It's not a big problem for companies like IBM, or Texas Instruments, but it is for start-up companies. Somehow you have to walk among these giants with your products and strategies without getting stepped on.

Q: What has led to this swing in market domination and how has the U.S. been able to hang onto its lead in the area of microprocessors?

The standard of living for the average person in almost all Asian countries is substantially lower than it is for our average worker. The motivation level of the average Asian, both in school and in their jobs is, I think, higher. I can't help but think that that's partially a result of the standard of living. That's why I think we're going to see some decline before we get motivated enough to really turn it around again.

We have an open market, which we look at as our industrial "policy." There need to be strategic industries and we need an industrial policy to protect them.

I don't see us at a disadvantage if I look at Chips and Technologies versus Sony or somebody like that. They're a lot bigger, certainly, but I don't think that in terms of coming up with product ideas or developing them they're any better.

The Japanese have done very well because they are very methodical and, if you give them a concept like a VCR or a TV or something like that, over a relatively long period of time, they're excellent at working out all the bugs and getting it down to the last fraction of pennies in terms of manufacturing it very cost effectively. That's why they own those businesses.

The PC business is different and has presented barriers to success for the Japanese. First, it's a very fast moving industry, and I don't think there was a particular target there long enough for them to really focus on as well. Second, the English language is a much better interface to a computer than Japanese or Chinese. Because you can't interface thousands of unique characters very effectively with the keyboard, they have to take a phonetics approach to it. On the other hand, we had a real advantage in that we have a very simple alphabet that lends itself easily to programming.

In Taiwan, outside of a few large companies, most were little companies that moved very, very quickly and operated on next to no margins. Thus, they were able to jump into the market quickly. They bought mother boards and put together PCs with inexpensive components. Ultimately, the difficulty with the Taiwanese model was there wasn't consistent quality. There wasn't even consistency in the components. They didn't use the same parts from computer to computer, so servicing became a huge issue. The advantages of the Taiwanese model ultimately wound up being disadvantages, which is one of the reasons we see more microprocessor and PC manufacturing activity in the U.S. now.

Q: You mentioned the word "quality." Has the U.S. been slow to accept the concept of quality?

No, I don't think so. You have to keep in mind that back in the sixties, we were the first mass producer. As we went into mass production, we had a very simplistic perspective on it. The idea was to make 100 units on a mass production line, and out of those 100, 90 would be okay. We'd ship those out.

When the Japanese picked it up, they said, "We can build production lines too, but we can actually perfect them. We can strive for higher yields." Part of their success was due to the motivation of the workers, part of it was due to the methodical approach they take, and part of it was being in this for the long term.

Don't forget that we live in an environment where the most important thing is next quarter's results. In Japan, they look at things a much longer term.

Q: Is it fundamentally more important to adopt a long-term approach in industrial development?

I think it would be one of the most important things we could do--if we had a rational industrial policy in this country. We have an open market, which we look at as our industrial "policy". That's unrealistic. There need to be some strategic resources, some strategic industries--and we need an industrial policy to protect them.

As a starting point, we have to take a more dominant role in trade negotiations. I think it's unrealistic for us to expect that we can have billions and billions of dollars of deficit forever. As president of this company, I can't run deficits forever. I have to be a break-even or profitable company. I don't think the country is any different. The president needs to figure that out and so does Congress.

If I had been Bush, I would have gone to the Japanese and said, "Look, we have to find a way to get to a more balanced state of trade. We can't afford to have this imbalance go on. It's in the best interest of both countries to see balanced trade. If it takes cutting off Japanese imports or consumer products to balance the trade, that's what we'll have to do--but I'd rather work this out in conjunction with you."

Then, I would have set a plan in action that would eliminate the trade imbalance at the end of a specified period of time. If that time frame was four years, the plan would call for a 25 percent reduction the first year, 50 percent at the end of two years, and so on. Instead, we went over and arranged for the sale of 20,000 automobiles--maybe. That's not the right approach.

Furthermore, I think we have to do a lot more to create the right environment for success. We have taken a positive first step by recognizing that we are rapidly falling behind. It should be a national priority to create an environment both conducive and encouraging to sustained investment. We should lower capital costs, pass a rational research and development tax credit law, and reintroduce capital gains preference. A capital gains tax preference would promote a long-term versus a short-term view of corporate performance. This is critical for the American semiconductor industry to survive and succeed.

We have the vision, technology, skills, and the will to continue to be the world leaders in integrated circuit design and manufacturing.

The electronics industry is the single most important industry for us to nurture as we approach the 21st century. We have the vision, technology, skills, and the will to continue to be the world leaders in integrated circuit design and manufacturing. What we do not have today is an environment that encourages us to innovate, encourages risk taking and the development of new and untried technologies. Let's create that environment. Let's allow Americans to do what they do best: innovate. ■

THE KING OF SMALL

EE's Stephen Chou continues his amazing record of success fabricating the world's smallest–and fastest–semiconductor devices.

In 1985, while still a graduate student at the Massachusetts Institute of Technology, Stephen Chou fabricated what was then the smallest transistor in the world. The channel length of Chou's transistor--some 600 angstroms, or roughly two millionths of an inch--was 17 times shorter (and thus much faster) than what was then the commercial benchmark for transistors.

Not long after, Chou became the first to observe the phenomenon of velocity overshoot in silicon transistors--which confirmed the theory that, when electrons travel in transistors with extremely short channel lengths, they can avoid collisions with the atoms of the semiconductor material and, thus, dramatically increase transport speed.

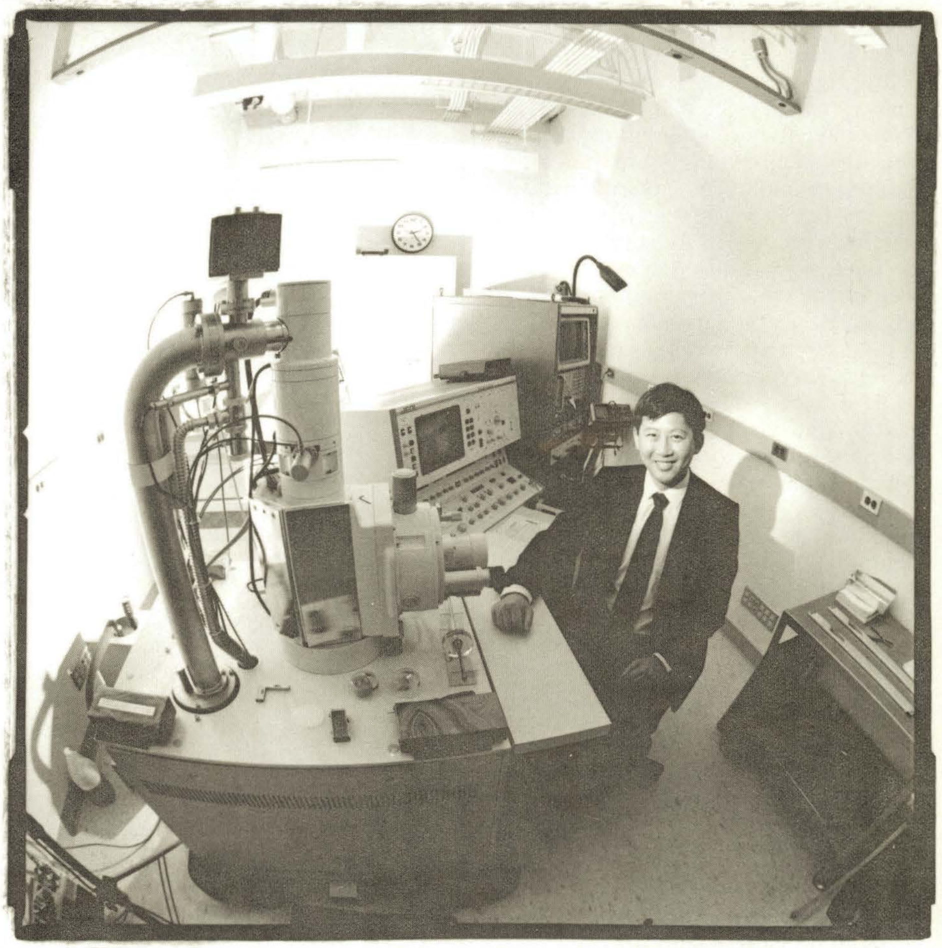
Given the rigors of graduate school and the impending challenge of securing the position he wanted at a prestigious university, it would have been completely understandable had Chou chosen to squeeze in a little R & R upon the successful completion of those research projects. But, for Stephen Chou, hard work is a given and the only way to reach the simple goal that drives him: "to go beyond that which seems possible."

While to the idle observer Chou may have already achieved that goal, Chou instead kept his nose to the grindstone, adding another half dozen "firsts" to his long list of accomplishments even before joining the IT faculty in 1989.

While at MIT and later Stanford University, where he served as an acting assistant professor, Chou fabricated not only some of the smallest and fastest devices ever before made, but devices with new architectures that offered increased opportunities to enhance the speed and functionality of semiconductor devices. While at Stanford, for example, Chou fabricated a transistor that has 12 separate states instead of the two separate states (on or off) of a conventional transistor, making it suddenly possible for a single transistor to perform the functions of 12 conventional transistors.

The names of many of Chou's new devices--wide quasi-parabolic quantum well resonant tunneling diodes; dual-

Photo by Rob Levine



EE Professor Stephen Chou with the electron beam lithography system he designed and built.

nanometer-gate lateral resonant tunneling field effect transistors--are as unintelligible to most of the rest of us as are the rules of cricket to a bleacher bum at Wrigley Field. Their importance as possible building blocks for the next generation of microelectronic machines, however, is clear.

"If the current trend of size reduction continues, within 15 years the miniaturization of conventional semiconductor devices will reach the limits imposed by the laws of physics," Chou says. "When the feature size of a transistor becomes comparable to the electron wavelength, the electrons in the transistor can no longer be regarded as classical point particles and their motion cannot be described by the drift and diffusion model. Instead, the electrons must be regarded as quantum waves and their motion described by quantum mechanics.

"The behavior of the transistor becomes completely different," Chou adds. "To continue the evolution of microelectronics, we need to develop not only advanced technology in fabrication and materials, but also a new generation of semiconductor devices founded on new principles, such as quantum effect devices based on the wave properties of electrons, and single-electron transistors based on the Coulomb repulsion of a single electron. They can offer ultra-high speed and new functions that cannot be provided by conventional transistors."

It is the promise of that unexplored ground that draws Chou forward through long hours of research, while at the same time writing numerous proposals, teaching, and meeting with the large number of students who clamor to learn from this man of many "firsts." Not all of his research hours, however, are spent dressed in a lab coat locked away in a subterranean clean room.

"Actually, I do a lot of work while driving in my car or doing something else," says Chou. "I always carry a notebook with me, and when I come up with a good idea, I write it down. The only problem is, the notebook already contains far more ideas than I will ever have time to accomplish."

Due to his hard work in constant pursuit of the next "first," Chou has experienced a meteoric rise through the ranks of scientists researching quantum-effect and other extraordinarily small devices. In 1990, Chou was named a Hewlett-Packard Fellow, an award that was given to just 20 professors nationwide who have demonstrated unusual creative ability in their research work. And, in 1991, he was named a University of Minnesota McKnight-Land Grant Professor.

Although he may not have the time to explore *all* of his ideas, Chou has nonetheless found time to add to his already impressive list of accomplishments since joining the IT faculty just three years ago.

When he came to Minnesota, it was with the intent of creating one of the best programs in the country for the fabrication and characterization of nanometer-scale semiconductor devices--a nanometer being one-billionth of a meter. And, according to those in the know, that goal has already been achieved with Chou and the people under his wing being the first to ever fabricate devices on a scale of 10 nanometers.

It's like developing the technology to travel into a new world where nobody has ever been before. In that new world, many things known no longer exist and the opportunity for new, innovative ideas are present at every turn.

Among the devices Chou has fabricated at IT are a new single-electron transistor, several new field-effect transistor devices that rely entirely on the quantum mechanical nature of electrons, and the world's smallest and fastest high-efficiency photodetectors. All of the devices Chou has developed offer the potential for exponential increases in the speed of a wide variety of computational and communications devices.

The single electron transistor, which is roughly 100 times smaller in area than conventional transistors, can effectively be switched "on" or "off" with a single electron rather than the 100,000 or so electrons required by a conventional transistor. Chou's various quantum-effect devices have the capability of registering multiple states, and, thus, of doing the work of several conventional devices in a fraction of the time. His world's fastest photodetectors can operate at a speed of about two orders of magnitude faster than that used in state-of-the-art fiber-optical telecommunication systems and is four orders of magnitude faster than the clock rate (i.e., the working pace) of today's fastest personal computer.

The key to Chou's success in fabricating these devices is what amounts to jury-rigged pieces of equipment and innovative technology that allow him to sharpen the "pencil" used to draw the tiny lines, gates, and circuits that constitute these devices.

To fabricate circuits of the dimension required for such devices, scientists use a very high-resolution electron beam lithography system. Commercial systems cost in the neighborhood of $3 million (plus annual operating and maintenance fees of roughly $200,000), making them unaffordable for most universities. (In fact, only two universities nationwide have such high-resolution systems: Cornell, which was established as a National Science Foundation nanofabrication facility to serve the country, and the University of Michigan, which landed a U.S. Army grant for a nanoelectronics center.)

Since Chou couldn't obtain funding to purchase a commercial system, he made his own--converting an electron microscope into a very high-resolution electron beam lithography system. The entire system cost him less than one-tenth of a commercial system, *and* the resolution is equalled by only one or two other universities throughout the U.S.

In addition to the fabrication facility, Chou's research group has a battery of testing equipment, from sophisticated computer-controlled electronics to a 17 Tesla superconducting magnet (the strongest field at any American university outside national magnet labs) and sub-picosecond lasers--a picosecond being one trillionth of a second.

"These are the stethoscopes we use to examine the performance of the nanodevices we fabricate," says Chou. "And, it's just the beginning. As we continue to improve our lithography system and develop new technology to fabricate even smaller structures and devices, we apply these new technologies to optoelectronics, magnetics, and many other areas where known theories stop working on such a small scale.

"For me, it's like developing the technology to travel into a new world where nobody has ever been before," Chou continues. "In that new world, many things known no longer exist. It's an environment in which devices are smaller than ever before thought possible and, consequently, where many fundamental physical parameters no longer apply. As a result, the opportunity for new, innovative ideas and applications are present at every turn." ■

Micro Magic!

Breakthrough research at IT bolsters the micro-machine revolution

By Chuck Benda

"The greatest scientific frontier in this century is the micro-world," an engineer from Tokyo University told *Newsweek* reporters in 1991. Other experts--from those at the NSF to Stanford--echo those sentiments. Some have gone so far as to predict micro-machines will foster a technological revolution that will make the invention of the transistor look like small potatoes.

The "revolution" started quietly enough at Bell Labs in 1987. Scientists there fabricated a few tiny gears (smaller than flecks of pepper) out of silicon--the same cheap, plentiful material used to manufacture computer chips. To the researchers' delight, their tiny gears twirled madly when they turned on the power (making them truly machines), but they didn't do much else. In the minds of scientific crystal-ball gazers, however, the cogs of imagination spun furiously.

If you could build machines on a micro-scale using materials and fabrication techniques comparable to those used to manufacture silicon chips, what doors would open?

Machines could be built not only incredibly small, but smart. A single chip could contain a machine (to transmit or change the application of energy), a sensor (to gather data from an external environment), and the "brains" (to interpret the data, tell the machine what to do and/or modify for the desired result), and monitor the outcome. Best of all, because these smart machines could be built using the same fabrication techniques as silicon chips, they would be dirt (or, if you will, sand) cheap.

With Jules-Verne-like audacity, the prognosticators began sketching a fantastic portrait of the new worlds they could boldly explore: mini roto-rooters that would traverse the human blood stream and cut away plaque to unclog arteries (perhaps even powered by the glucose in human blood); tiny mechanical tongs, guided by chemical sensors and microprocessors--all on the same chip--that swim through contaminated water supplies and pick out the pollutants; single chip, implantable pharmacopoeias that monitor body chemistry and administer micro-doses of drugs as needed to maintain the delicate balance necessary

Photo by Rob Levine

EE Professor Dennis Polla in his micro-machine laboratory.

for good health.

Although a good deal of hard research remains to be done before these fantasies become reality, in the five years since the first gears began spinning at Bell Labs, remarkable progress has been made. Researchers at the University of California--Berkeley made a micro-motor smaller than a pin-prick that ran continuously for nine months and achieved 15,000 rpms (more than twice the typical "red-line" speed of an automobile engine). Researchers at the University of Wisconsin, Madison, fashioned micro-motors out of nickel, which is less brittle and therefore more durable and practical than silicon. And recent breakthrough research led by IT Electrical Engineering Professor Dennis Polla promises to bring the fantasy one step closer to reality.

IT Leads the Way

Polla and company joined the micro-machine fray soon after the work at Bell Labs was reported in 1987 using the same process called surface micro-machining.

Similar to the technology used to make silicon chips, surface micro-machining includes depositing layers of polysilicon and sacrificial materials on a silicon substrate. The polysilicon that is to become the "structure" (a gear, a cantilever beam, a diaphragm) is "marked" using a mask and standard optical lithography techniques. The surrounding polysilicon and the underlying sacrificial material is then removed through acid etching, leaving the desired structure in place on the substrate.

Beginning in 1988, Polla, Electrical Engineering Professor William P. Robbins, and their colleagues began to explore a variety of applications for surface micro-machining. They developed rudimentary stepper motors, sensors, micro-actuators, and a variety of processing circuitry to interpret and direct their micro-machines. Here and there they refined certain techniques developed elsewhere, essentially keeping pace with research going on at other institutions.

A breakthrough in early 1990, however, catapulted Polla and company into the first rank of researchers in micro-machine development.

At the Cutting Edge

In the mid-1980s, scientists began exploring the properties of a compound, lead zirconate titanate, or PZT, for a variety of applications, including use on their sensors.

"PZT has extremely high piezo-electric and pyro-electric coefficients," Polla says, "but nobody knew how to deposit this material on a silicon wafer in a thin film."

In layman's terms, those high coefficients mean that PZT is roughly 20 times more sensitive to pressure and 80 times more sensitive to heat than the material then being used--zinc oxide. If PZT could be deposited on the surface of micro-structures, it would open the door to a whole new world of applications based on extremely sensitive and accurate sensors.

After much trial and error, Polla and his cohorts hit on a technique in 1990 to deposit the material on silicon.

"We used a gel form of PZT and an ordinary eyedropper to place it on a spinning wafer of silicon," he says. "By changing the rate of spin, we were able to control the thickness of the layer deposited. Once the gel was in place, we placed the wafer in a curing oven to solidify the PZT."

Although developing a deposition method constituted an enormous breakthrough, several problems remained. The IT group soon discovered that their film had some of the desired properties, but it was not as sensitive as PZT in bulk form. And, in some cases, the sensors became "brittle," breaking in response to stress rather than deflecting.

"We spent last year tinkering--doing a lot of materials physics," Polla says. "It's possible to vary the properties of PZT by changing the composition of zirconium, so we were searching for optimal combinations."

Once their characterization studies were completed and the optimal combinations determined, the IT team was off and running.

When Polla says that this is one of the hottest things going in micro-machines, it's easy to understand why. All you have to do is take a look at some of the devices they've already developed.

The piezo-electric properties of PZT have been used to develop an acoustic pressure sensor that may soon be adapted for commercial applications, such as in powerful yet inconspicuous hearing aid devices. In simple terms, a diaphragm coated with PZT deflects in response to sound waves and produces an electric charge that can be measured, allowing the device to "hear" sounds 50 times quieter than what the human ear can detect. The sensor has a surface area smaller than a cross-section of a human hair. And, because thousands of the sensors--along with the processing equipment to interpret the signals--can be manufactured on a single silicon wafer, the technology promises significant cost savings.

Similarly, Polla and his colleagues have fabricated accelerometers, that consist of PZT-coated micro-mechanical beams and the corresponding processing circuitry. The accelerometers they fabricated may replace the systems used to activate automobile air bags as early as 1997 or 1998. Current technology relies on a sensor and a separate microprocessor and costs about $150. The IT unit is self-contained on a single chip, offers superior sensitivity, has a much quicker response time, and could be sold for about $5 to $10 a piece.

Micro-machine acoustic sensors smaller than a cross section of hair can "hear" sounds 50 times quieter than what the human ear can detect.

The pyro-electric properties of PZT have led to the development of a fascinating infrared detector array that may one day provide local police an extra margin of safety. On a single wafer of silicon not much larger than a postage stamp, the IT team has fabricated an array of 4,096 infrared detectors and necessary processing circuitry to turn the signals into a video image on a television screen.

The PZT coating on the individual detectors produces an electrical charge in response to the infrared radiation (heat) striking it. The processing circuitry measures the charge from each detector and sequentially activates each of the 4,096 pixels on a television screen, creating a dynamic image that can be used to see in the dark. One application Polla foresees is the development of affordable night-vision goggles that help policemen see in the dark when duty calls them into dangerous situations. (Current night-vision devices, which rely on different technology, are extraordinarily expensive and often cumbersome to use.)

Beyond the realm of their super-sensitive sensors, the IT team of micro-machine researchers has also developed micro-valves and micro-actuators to open and close them, as well as stepper-motors to pump liquids through the valves and micro-vacuum tubes. These valves and pumps could be used to precisely mix extremely small amounts of chemicals (a company attempting to synthesize DNA is currently interested in these devices) or in implantable drug-dispensing units. The micro-vacuum tubes, on the other hand, can function as transistors in very high-temperature environments where traditional silicon transistors fail--such as in an automobile carburetor. Here they could be used to monitor and control fuel mixture and help increase mileage and performance.

Just five years have passed since the first micro-gears were fashioned at Bell Labs. The progress in micro-machine technology during that time has been remarkable. But are micro-machines going to change our lives any time soon?

Back to the Future

"The next step for us is to develop what I call 'smart systems,'" Polla says. "We've been able to make micro-sensors now, and we've been able to make circuits and actuators. Now, we'd like to be able to put the three together. One of my students--Peter Schiller--has begun a project that will sense pressure and acceleration and temperature, process that information through circuitry, then have the circuitry respond back onto the environment to say, 'Close this valve a little more because the pressure is too high.'"

Polla and his group, as well as other researchers around the country, have completed part of the picture--but, unfortunately, a lot of pieces are still missing. For example, while researchers at the University of California--Berkeley have created mechanical tongs capable of grasping single-cell sized objects, they are a long way from having a self-contained system that can direct itself through a container of polluted water, decide which particles to grasp, and then do something useful with them. Similarly, various motors have been developed that spin furiously--but they don't actually "do" anything. How great is the gap between a nifty micro-motor that spins and spins and a precise surgical tool that can navigate the blood stream and clean out the bad stuff without damaging the good stuff?

"Some of these ideas--like this human roto-rooter concept--are quite far-fetched," Polla says. "They can make the gears and the machines, but to be able to control them and have them operate autonomously within the human body--without cutting into something important--requires more than these technologies can deliver now, or probably even 50 years from now. I don't think I'll see it in my lifetime.

"The concept of chemical reservoirs, implanted in a body, and controlled by sensors and processing circuitry, however, is very close to fruition. It's already being done with devices that are pre-programmed to administer doses at regular intervals.

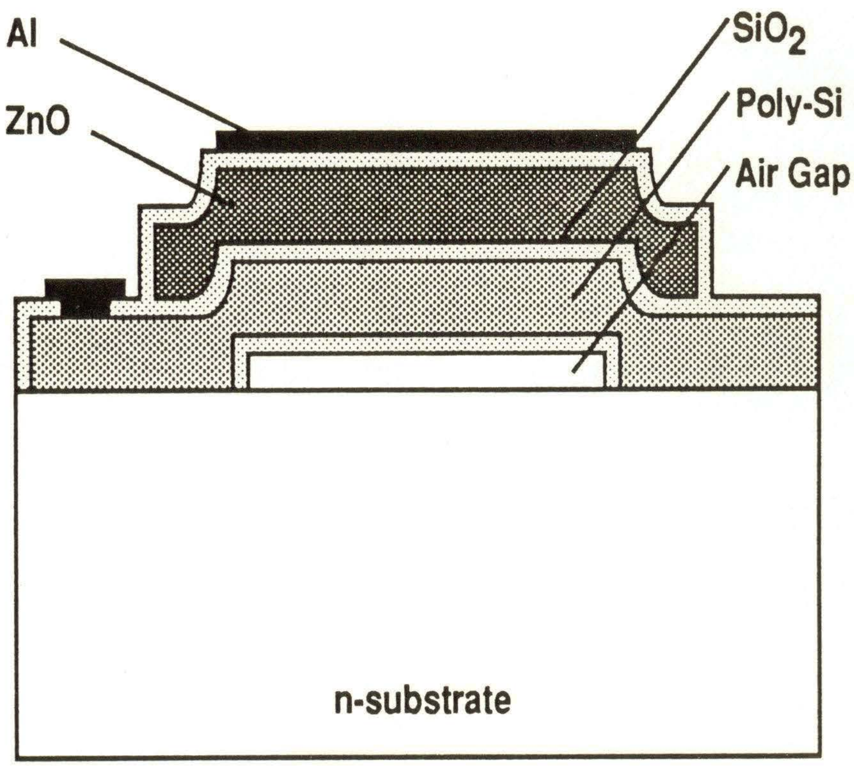
"In the short run, I think we'll see micro-mechanical devices used for extremely simple types of things. For example, circuit breakers for electricity distribution networks--which are currently very expensive--could be made very cheaply. Very light weight mechanical switches could also be made for use in aircraft.

"But taking a $150 device and replacing it with a $5 to $10 item--that's not revolutionary. So far, almost every form of activity in this community has been applying micro-mechanical devices to replace something else that is either too large, power hungry, or costly. Likewise, what we've done with our acoustic sensors presents a big advantage--hearing impaired people may be able to hear things they couldn't before, using smaller devices, at more economical prices--but that's not revolutionary. In order to consider this a revolution, we need something new that isn't doable with current technology."

While the skeptic in Polla maintains a healthy air of caution, there is still excitement within the scientific community. And private industry--especially in Japan and Europe--is paying close attention to new developments in micro-machine technology.

Perhaps Polla's restraint is simply a scientist's way of focusing on the thousands of little breakthroughs needed to bring a new technology to fruition. After all, the Wright brothers were just aiming for a spot a few hundred feet away in the sands at Kittyhawk when they launched their first airplane, and, in less than 25 years, Lindbergh was merrily winging his way from New York to Paris. Can it be that long until we're able to clean up an oil spill by turning loose a horde of micro-mechanical pac-men to gobble up the mess?

Vive la révolution! ■



Polla and his colleagues developed a method to replace the zinc oxide (ZnO) in this typical micro-machine sensor with the compound PZT, creating a new generation of sensors 20 times more sensitive to pressure and 80 times more sensitive to heat.

Education. Our Best Investment for the Future

Like the people from his native Korea, Sang Joon Lee believes nothing is more critical to personal and professional success than education.

By Chuck Benda

Sang Joon Lee (71/EE), founder and president of American Neuralogix.

Sang Joon Lee's biography would make a marvelous Horatio Alger story. Young man comes to strange new country, shares small boarding room, scrapes by on the hard earned dollars his family sends him. Works long, hard hours through graduate school and at his first job (with Honeywell Inc.). Climbs through ranks, becoming highly successful and much respected for the work he does.

Successful company from his homeland (Samsung) recruits him to start a new division in Korea (Samsung Semiconductor). After many more long hours and much hard work, new division is wildly successful and becomes a source of national pride--but our protagonist decides it's time to move on to a new challenge and founds his own company in Silicon Valley (American Neuralogix), hoping, once again, that diligence and perseverance will be rewarded with success.

The future economic health of America depends on reaffirming our belief in the value of education at all levels.

Such a story would be--and is--fascinating, but to Lee, that story is not the most important one he has to tell. What is important is what made it all possible. And for him, that comes down to one word: education.

"There is no better long-term investment than education," Lee says, and as proof, he tells of the changes that have taken place in Korea since the government and the Korean people realized in the mid-1950s that education was their only hope for escaping the hardship and poverty of life as an underdeveloped country.

"Korea is about the size of Kansas and roughly 75 percent of the country is wasteland--hilly and mountainous, with very little forest land," Lee says.

With few natural resources and a large population (Korea has typically ranked third or fourth in the world in terms of population density), intense poverty was a seemingly inescapable way of life for most Koreans.

"Korea doesn't have anything except people," Lee says. "The only way they can survive is by bringing in raw, unfinished materials and producing value-added goods for export."

Fortunately, Korea's first president after World War II, President Rhee, the holder of a Ph.D. degree from Princeton, understood the problem and the solution.

"He was a visionary man," Lee says. "He saw that the future of Korea was education."

By the early 1960s, the push for more and better education led to a trickle of Korean students going abroad to study. Lee joined the ranks of those early travelers, enrolling at the University of Minnesota in 1963. The trickle soon became a torrent (in the late 1970s, roughly 30 percent of all Ph.D.'s granted in the U.S. went to Korean-born students) and Korea's economy reaped the rewards.

"At the time I left Korea, the annual per capita income was roughly $83," Lee says. "When I arrived at the University, an article in the *Minnesota Daily* listed the University's biennial budget as $250 million. The Korean national budget was $250 million. Today, the per capita income is $5,000-$6,000, and the government's annual budget is $45 billion. Education--and nothing but education--has been the key for Korea."

Lee's personal success and the remarkable success of his homeland have solidified his belief in the importance of education to solid economic growth. And the slip in American competitiveness in the international marketplace has him worried about the future of American education and economic growth.

According to Lee, part of the reason for the problem may be that Americans can get relatively good jobs with only a high school education, whereas citizens of countries like Japan, Korea, and China must pursue higher education merely to survive. He believes the future economic health of America depends on reaffirming our belief in the value of education at all levels.

Lee's educational experience and the skills and tools he developed while working at IT under the guidance of former Electrical Engineering Professor Aldert van der Ziel, is testimony to these ideas.

"I wasn't sure where I was headed while I was doing my master's and Ph.D. work," Lee says. "I had two kids at the time, living on a research assistant's salary, building up debts. But I was a proud young man. Perhaps I wasn't the smartest, but I learned that if I worked hard I could get someplace.

"I still feel like that Ph.D. candidate. I still work hard. I am at work at 6:30 in the morning and never go home until 7:00 at night. It gave me momentum because it was exciting. That's what education is all about."

That excitement is what helped Lee succeed in the various positions he has held during his career. And that excitement is what Lee hopes will help him reach his goal with American Neuralogix--to build it into a $100-million-dollar company before he retires.

American Neuralogix is still a small company, with just over a dozen employees. Their initial successes have come in the area of micro-controllers for consumer electronics products that use either fuzzy logic, neural logic, or a combination of the two. Yet, they have 14 patents on their work thus far and, given Lee's track record, his goal doesn't seem unrealistic. The investment Lee made in his education has obviously paid off handsomely for both the U.S. and Korea. And, when and if Lee meets his goal of developing American Neuralogix into a $100 million company, perhaps his example will convince others that education is the most important investment we can make in our future. ■

The Power of Alumni Giving

Pictured at the dedication of the Edgar F. Johnson professorship (left to right): Charles M. Denny, Jr., Johnson's daughter, Lois Chaffin, University of Minnesota Regent M. Elizabeth Craig, Oscar A. Schott (34/EE), John D. Somrock (68/ChemE), and William G. Sheperd (33/EE). Seated: Johnson's granddaughters, Tecla Forsman and Molly Rinowski.

Alumni gifts have long played a crucial role in supporting the Institute of Technology and helping us remain a leader among institutions of higher learning. As state funding levels continue to decrease we have been forced to rely more than ever before on alumni support to maintain our first-rate science and engineering programs.

Throughout the years, private contributions have come from individuals, married couples, foundations, companies, groups (such as reunion classes), and professional societies, all of whom share one thing in common: they care about our future and understand the need to invest in the process of inventing tomorrow. Inventing tomorrow--by educating engineers, training scientists, creating new technologies, and arming the nation with the tools it needs to tackle the future--has been and continues to be our primary mission.

Our success toward that end has come about largely through private gifts that support future scientists and engineers with scholarships, allow faculty and graduate students to further critical research, and give students opportunities to stay on top of current technologies. Through your help, our record is outstanding. IT's entrepreneurial alumni alone have founded more than 550 companies that employ more than 130,000 people and generate annual revenues in excess of $15 billion. And that's only part of the story.

There are many reasons to give. In addition to the tax advantages and the desire to help IT meet its basic needs, alumni make gifts to:

- pay tribute to a favorite teacher
- remember a friend
- memorialize a family member
- recognize a company
- mark a special occasion.

You can help support IT and invest in the future with cash, through life insurance and annuities, with a bequest, or any number of other ways.

Don't put off joining your fellow alumni and friends in supporting the Institute of Technology. Use the postage-paid envelope between pages 36 and 37 to send your contribution or request more information. By investing today you will help invent tomorrow.

Take a look at the possibilities and the difference such gifts can make.

IT Equipment Endowment

As state funding continues to decrease, fast-paced technological developments have made much of IT's instructional equipment obsolete. When Herbert C. Johnson learned of IT's equipment needs, he established the IT Equipment Endowment Fund, which has since grown with the generous help of several corporate sponsors.

The Frank Louk Scholarship Endowment

In memory of her husband, Aleyene Louk created the Frank Louk Scholarship Endowment to help financially needy engineering students receive the education they desire. A portion of Mrs. Louk's estate will create a permanent endowment forever honoring Frank Louk (1930/CE). Since 1987, 11 students have received $13,000 in scholarships.

The Tom Murphy and B.J. Robertson Scholarship

Outstanding faculty are often honored by their colleagues, but it is especially rewarding to be honored by former students. In admiration of Mechanical Engineering Professors Tom Murphy and B. J. Robertson, William N. Blatt (1949/ME) created a fund to benefit mechanical engineering students carrying on the work with internal combustion engines that Murphy and Robertson began. The research continues, and since 1985, five students have benefitted from Blatt's thoughtfulness.

The Chemical Engineering Computation Center

In 1986, a group of chemical engineering alumni saw a desperate need to enhance study space and equipment for undergraduate chemical engineering students. Together, they raised more than $40,000 for 14 new computers, software, and printers, as well as new furnishings for the Chemical Engineering Computation Center. Thanks to their support, life is a little easier for the numerous undergraduate students who use the Center each day (and often long into the night) completing homework and studying for exams. Their support shows how numerous individual contributions when combined in a group effort can make a big difference.

The Edgar F. Johnson Professorship of Electronic Communications

As a young radio communications wizard, Edgar F. Johnson (1921/EE) founded the E. F. Johnson Company in Waseca, Minn. Upon his death, Johnson's friends and family pooled their gifts and, with matching support from the E. F. Johnson Foundation, created a $500,000 professorship to continue Johnson's pioneering efforts in innovative communications research.

The John N. Clausen Memorial/IT Tutorial Fund

Many IT alumni remember Professor and Assistant Dean John Clausen as a man who cared about students. While serving as assistant dean for student affairs, Clausen established the IT Tutorial Fund to enhance advisory services for students. Upon his death in 1991, IT established the John N. Clausen Memorial Fund to ensure Clausen's legacy as an advocate for students would live on. Recently, alumni contributions to the fund helped establish the freshman team concept through which faculty and peer advisors are assigned to teams of IT freshmen who take classes and work together. Gifts to IT can be earmarked for this fund to help ensure Clausen's memory and efforts carry on.

The Kvitrud Fund

In the early 1960s, Ingwald Kvitrud established a trust for he and his wife, designating that, upon their death, the remainder of the fund would go to IT. Their foresight and generosity, which will long be remembered, resulted in a gift of $80,000 to IT.

The Bonestroo, Rosene, Anderlik & Associates Undergraduate Scholarship and Faculty Award Endowment

In 1987, Otto Bonestroo (1949/CE), Robert Rosene (1945/CE), and Joseph Anderlik created an endowment named after their consulting firm with each partner chipping in $20,000. Today, interest on that endowment generates enough income each year to fund an undergraduate scholarship for an outstanding civil engineering student and an award to an outstanding faculty member. Since, 1987, four civil engineering professors have received awards totaling $7,200 and four students have received scholarships totaling $7,600.

The Glover-Steinmetz Scholarship

Each year, the General Electric Company (GE) presents their outstanding engineers and scientists with the Charles P. Steinmetz Award, an award named after the mathematical genius who helped shape the electronics industry. When Gary Glover (1964/EE) received the coveted Steinmetz Award for his work with GE's computerized tomography scanner in 1985, he signed over the $10,000 he received in conjunction with the award to the Institute of Technology to help freshmen in electrical engineering, mathematics, or physics.

The Inventing Tomorrow Fund

To show his satisfaction with the IT 400 issue of *ITEMS*, Steven Bauer (1978/AgE) sent a contribution for future publications of the magazine. He also sent a big vote of confidence! ITEMS is currently offered free of charge to all IT alumni. However, because production and mailing costs run upwards of $40,000 per issue, additional alumni support is needed to avoid having to charge subscription or membership fees.

The Inventing Tomorrow Fund also helps to defray the costs of IT Week. The Corporate Leadership Forum, the centerpiece of IT Week, offers growth through learning from our alumni experts. ■

Salute!

Private funding is essential to maintaining the high quality of education the Institute of Technology provides its students. Because of your support, deserving students receive scholarships they need to continue their education, and faculty and students have access to better equipment.

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Barbara and Glenn Ullyot

Home:
Kimberton, Pennsylvania

Career:
Glenn Ullyot earned a bachelor's degree with distinction in chemistry from the University of Minnesota in 1933. He went on to earn a master's degree (1935) and Ph.D. degree (1938) in organic chemistry from the University of Illinois. Ullyot spent the bulk of his professional career working for Smith, Kline & French Laboratories where he specialized in research management and medicinal chemistry. He holds some 30 patents and has been active in numerous professional societies throughout his career, including the American Chemical Society.

Family:
Glenn, 81, and his second wife, Barbara, divide their time between their home in Kimberton, Penn. and their condominium in Annapolis, Md. Barbara is a former employee of the American Chemical Society.

Recent Gift:
Using a charitable gift annuity, the Ullyots created the Glenn P. Ullyot Scholarship Fund to support students who wish to pursue a degree in science and engineering at the University. The scholarship will provide one student each year with approximately $5,000 to further his or her studies. Preference is to be given to students from the Ullyots' home town of Clark, S. D., then the state of South Dakota, and finally Minnesota.

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IT DONOR PROFILE

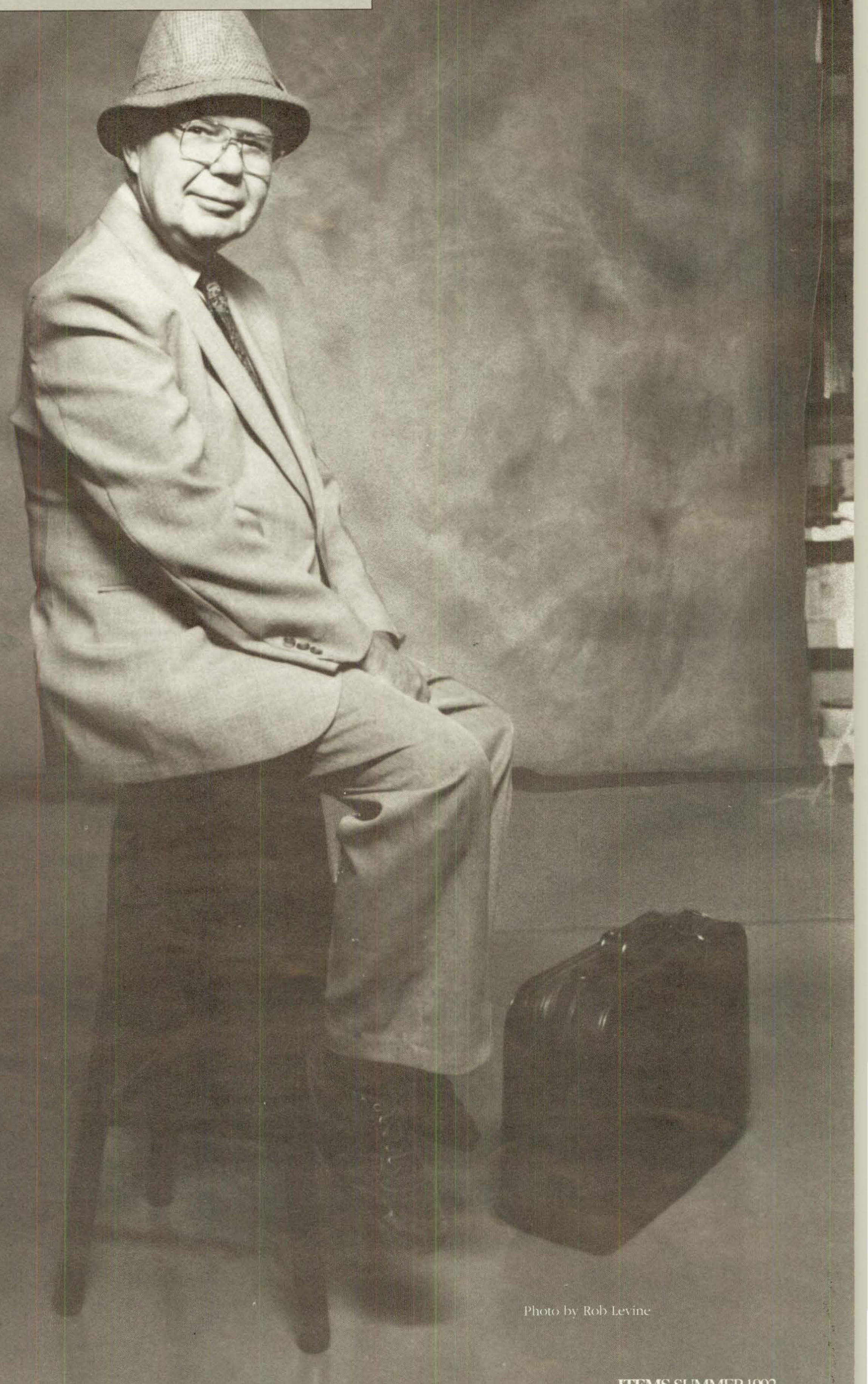
William J. Feyder

Home:
St. Paul, Minnesota

Career:
William Feyder graduated from the Institute of Technology in 1932 with a bachelor's degree in electrical engineering. In 1933, he joined Druar & Milinowski Consulting Engineers where he worked until 1941. He then took a position at Dupont's St. Paul ammunitions plant. In 1944, he transferred to Dupont's Oak Ridge, Tenn., facility where he became manager of engineering operations. In 1947, Feyder went to work for Toltz, King, Duvall & Anderson, serving as a senior engineer in the firm's engineering services division. Although his professional life has slowed a bit in recent years, Feyder denies ever really retiring.

Recent Gift:
Feyder named the Institute of Technology as a primary beneficiary in his Last Will and Testament. By doing so, Feyder became a member of the University of Minnesota's Society of Builders for the Future--an organization established to honor those making financial contributions of $1 million or more, either through a current or future gift.

Quote:
"I placed the Institute of Technology in my will because I am grateful for the education I received and I feel it is the place where my money will do the most good." ■



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IT DONOR PROFILE

Harold and Anale Van Wagenen

Home:
Cincinnati, Ohio

Career:
Harold Van Wagenen earned his bachelor's degree (1936) and his master's degree (1938) in chemical engineering from the Institute of Technology. Upon graduation, Van Wagenen went to work for the Texas Petroleum Company (Texaco). He served in the U.S. Army from 1941 to 1946. Upon discharge, Van Wagenen joined Procter & Gamble. During the next 30 years he served as a group leader in research and development for that company. Following his retirement in 1976, Van Wagenen joined the National Institute for Occupational Safety and Health, working there until 1987.

Family:
Van Wagenen has four children from a previous marriage. He and Anale were married in 1976.

Recent Gift:
The Van Wagenens have established a trust fund that will be used to support two programs named in honor of Harold's late father, Marvin J. Van Wagenen, a former professor of psychology at the University of Minnesota. These programs are the Marvin J. Van Wagenen Scholarship and the Marvin J. Van Wagenen Fellowship.

Quote:
"My father always talked-up the virtues of an education at the University of Minnesota. He was on the faculty there for 35 years and I wanted to set up a program in his memory." ■

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