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Volume 92, No.1

October 1987

# wisconsin engineer

## A New Location for Your Education

- A New Face for Placement Office
- A New Look for MME Lab

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Madison, WI 53706

Cover by Lisa Van Dyke

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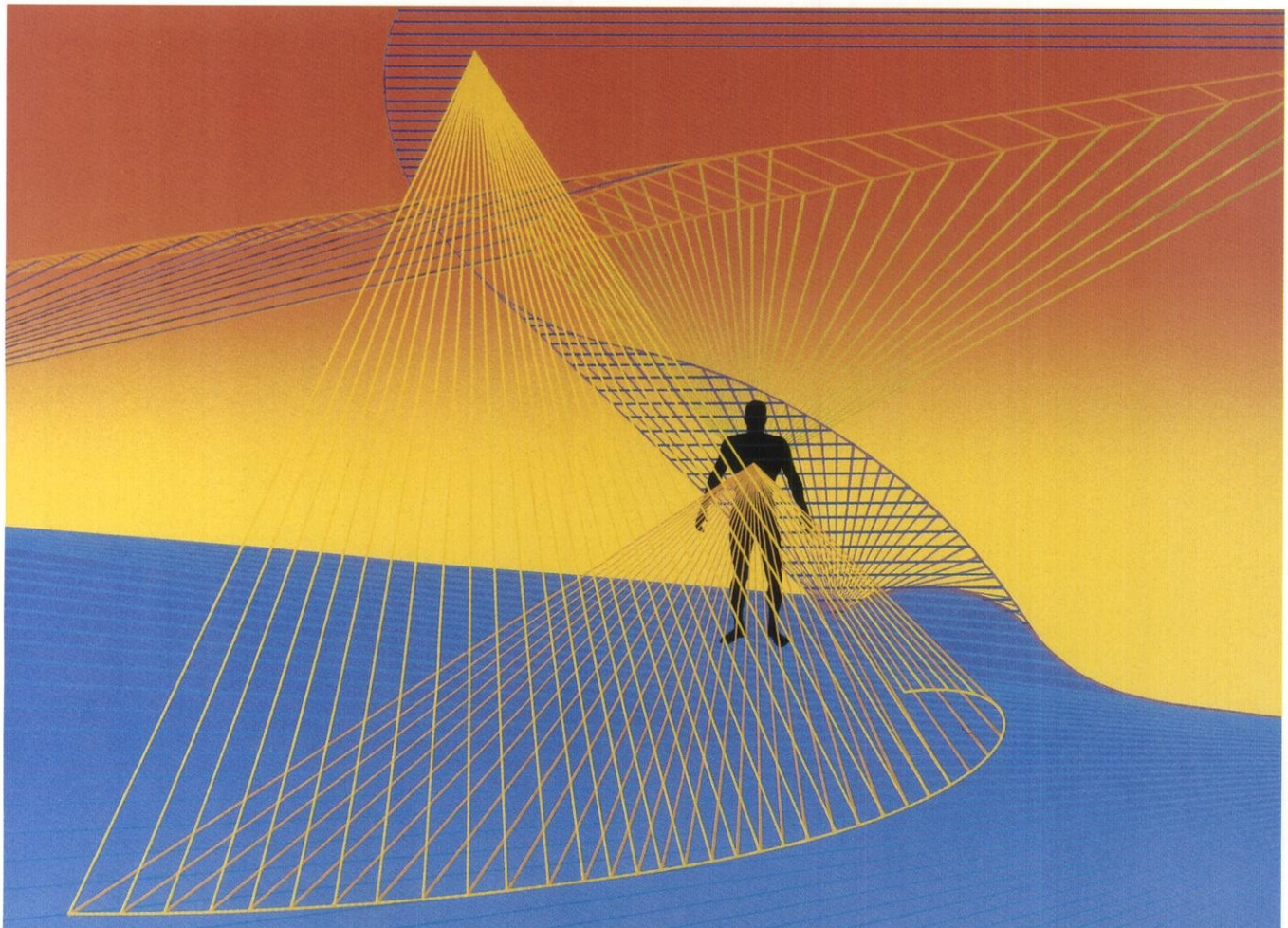

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# wisconsin engineer

PUBLISHED BY THE ENGINEERING STUDENTS OF THE UNIVERSITY OF WISCONSIN-MADISON OCTOBER 1987



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# Editorial

# Raccoons, SDI, and My Bike

It was quite cold last night when I rode my bike home from the first layout meeting of this issue of the **Wisconsin Engineer**. I bought the bike at the beginning of the summer to ride every day around the lake (Ha!), and it was quite expensive; it's a Japanese racing bike—pushing the frontier of lightweight/super-strong materials and economical design. There is a small mountain near my home, about 50 feet high, sitting at the intersection of four streets. It is out of place in my densely populated neighborhood, and I am surprised it was not flattened to allow for easier snowplowing in winter. Graves and ancient Indian mounds lie about it—maybe that's why. Anyway, I rode my expensive bike around the mountain, enjoying the speed and freezing air. On my fifth loop I glimpsed a raccoon strolling down the hill, pawing at the dried leaves, and I screeched my high-tech brakes to a stop.

I jumped off my bike and the raccoon dashed into a nearby drainage ditch cluttered with fallen leaves; I walked up to the ditch, hoping to meet him (her?). He peered out, stared at me for few moments, and then disappeared. I sat and waited for him to reappear for awhile, convinced that my silence would fool him, and he would return to poke around in the leaves. He didn't— I finally realized that he had not peeked out of the ditch earlier to see if I was gone, but rather simply to observe my strange behavior. I wonder if he hadn't become used to seeing humans playing with high-priced gadgets, because he seemed very curious.

Humans do strange things with money. We buy food, bikes, space-based directed energy weapons, water, clothes.

I felt like a raccoon at a recent lecture I attended on SDI. Nicolaas Bloembergen, Harvard professor and founder of non-linear optics and laser spectroscopy, spoke on the science and technology of directed energy weapons. He and sixteen others formed a group in the aftermath of Reagan's March '83 "Star Wars" speech to study the feasibility of the program, and their findings were recently published in Modern Physics. The requirements for membership in the group included previous lack of public opinion on the issue, as well as extensive physical backgrounds. They had full government cooperation and access to classified material, so no one in Washington could say "If you only knew what I knew..." Bloembergen spoke easily about particle beams and survivability, about free-electron lasers ("Every new baby is a genius," he jested) and about basing requirements. He spoke about system problems, such as the lasers not working "if there are clouds overhead." He received quite a few laughs throughout his presentation, especially when he explained the orders of magnitude in improvement of existing technology necessary before we have enough knowledge to make informed decisions about the feasibility of space-based weapons.

Well, I didn't think it was very amusing truly, and I doubt the raccoon would either. Professor Bloembergen made it clear that the cost of these weapons systems was not considered in their study; they kept politics out of the discussion. The group essentially concluded that the SDI program as espoused in 1983 is not viable for the foreseeable near future (hence recent administration moves toward kinetic energy weapons instead). But Bloembergen surprisingly still advocated research on the super high-powered lasers, etc. because "it would be interesting to know."

Well, I agree with his interest, but not his advocation. I think you can only keep money out of the equation for so long, in an age where superconducting supercolliders must compete with poverty-stricken Americans for government monies. I am all for basic research, and for food and shelter. Increased threat of nuclear annihilation aside, I just don't think that we have the money to waste on "Star Wars" gadgetry. If I spend my money on an expensive gadget, I can only blame myself if I fall on my face. But I can also only hurt myself, and that's one thing that SDI and my bike don't have in common.□

# Dean's Corner

**By Dean John Bollinger**

In talking with students, I have come to realize that many do not ever see a copy of the "College of Engineering Annual Report." This is the only publication that provides a broad summary of the operations of the College of Engineering. The Annual Report is sent to thousands of alumni, corporations, friends of the College, and other universities. I would like to share with you the changes here in the past few years, and especially in the 1986-87 period that are reflected in this year's report.

I will take you on a brief tour that will touch on a small part of our research, teaching, and public service. You will see a few of our laboratories, classrooms and faculty members. However, I believe this small sampling will demonstrate our leadership in advanced technology and our service to Wisconsin and the nation.

We are a college of about 200 faculty members, 5000 students, and 350 staff. Our budget is approximately $50 million per year, and eighty percent of that comes from federal agencies, industry, and other outside sources rather than from state taxes. Our faculty receive outside funds, in competition with researchers from other schools, because of their outstanding achievements and creative ideas.

In the past few years we have worked to shape the college's direction in these ways:

- We have reduced undergraduate enrollment to about 3,600 as of fall 1987, a number that allows us to provide the student with a first-rate education given, our current faculty size and physical resources.
- We have expanded our research programs by winning outside funding in many areas of engineering. Because research programs provide financial support for graduate students, we also have slowly increased our graduate student population.

These research programs also benefit our undergraduates. Some undergrads get direct research experience by working in our laboratories. All undergrads get the most up-to-date education possible from teachers who are creating knowledge in their fields.

- We have recruited a substantial number of new faculty members. In many cases we did this as other faculty retired, but often not in the same area or even the same department as the person who left. In this way we have moved into new technologies. Most of these new people are young and show great promise of developing strong research programs and attracting the funds to support them.

To begin our tour of the college, I'd like to show you the steps we are taking to ease our growing space problems. This summer, the Wisconsin legislature and Governor Tommy Thompson approved a $16.5 million addition to our Engineering Building. The addition will fill part of the courtyard between the electrical and computer engineering and chemical engineering wings. More than 65,000 square feet of space in the new addition will provide laboratories and offices for electrical and computer engineering, chemical engineering, and other departments.

The addition's centerpiece will be a 500-seat Technology Transfer Auditorium that can be partitioned for use by two or three smaller groups. This and a large student study lounge will be built with private funds.

To the north of the site for this addition, across Johnson Drive, a smaller construction project is already in progress. This is an addition to the former highway laboratory, which will house our Computer-Aided Engineering Center, rheology research and polymer characterization work, Thin Film Deposition and Applications Center, and other research.

Our Wisconsin Center for Applied Microelectronics moved into this same building two years ago. With the U.S. electronics industry working hard to overcome international competition, our strengths in integrated circuits, microscopic sensors and mechanical devices, and related materials science areas are attracting a great deal of attention.

Our strengths in microelectronics were evident in late summer articles reporting that Wisconsin was one of six states still in the running for the national SEMATECH research center, which will be built by a consortium of leading microelectronics companies. Thirty-six states had submitted proposals. Whatever the outcome, our position as a finalist shows just how strong our state, university, and College of Engineering have become in advanced technologies.

*Students relaxing at the Engineering Building— a rarity.*

We now walk a short distance to the northeast, where our Wisconsin Center for Space Automation and Robotics (WCSAR) is located in the Rennebohm building on University Avenue. We established this center in the summer of 1986 with a $5 million grant from NASA and cooperation of three other Wisconsin universities and twelve industrial sponsors.

WCSAR has three major research programs:

- Automation and robotics, which develops technologies to augment man in space for tasks such as assembly and service of space stations, satellites, and production facilities.

● Automated plant growth systems, which will develop space-based plant growth units to provide food for the people who work in space.

● Automated lunar resource processing system, which capitalizes on the recent discovery that the moon's surface contains, in the isotope He-3, more than 10 times the energy in all of earth's fossil fuels. This research is developing ways to retrieve He-3 for use in fusion reactors on earth.

We have some other exciting space-related work in this college. The Engineering Mechanics Department plans to have an astronautics option available to its undergraduates next fall; it already offers a number of courses in this area.

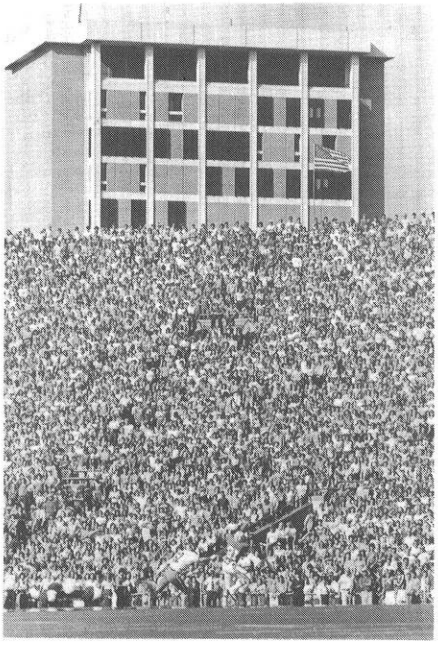
A walk west on University Avenue from our space center leads to the Metallurgical and Mineral Engineering (MME) Building, a focus of the activity for a brand new undergraduate degree program in mineral exploration and the management of earth resources.

We have phased out our traditional mining engineering program and this fall we began the Geological Engineering Degree Program, which integrates the disciplines of geology and engineering. Graduates will be educated to design or analyze man-made structures in rock or soil such as dams, tunnels, and underground power plants; or help mitigate naturally occurring phenomena such as floods, landslides, and earthquakes; or to develop safe and environmentally sound subsurface openings for mineral extraction, energy storage, or waste disposal.

Continuing on our tour, we walk from the MME Building next door to the Engineering Research Building, which houses more research in superconductivity. Our Applied Superconductivity Center, with Professor Roger Boom as director, has been a leader in this field since its founding seventeen years ago and has educated many of the engineers working in this technology worldwide.

Professor David Larbalestier and his colleagues here have developed helium-technology superconductors that are used in most of today's superconducting magnets. They produced these conductors by integrating three areas: advanced metallurgical studies of the material, understanding of physical and electrical-current-carrying properties, and fabrication technology. These conductors, cooled with liquid helium, can carry great amounts of current and withstand enormous forces produced by their magnetic fields. They are used in particle accelerators, fusion energy research, and medical imaging technology.

While the new, higher-temperature superconductors are very exciting, the helium-temperature devices will have an important role in high-current applications for many years to come. The work by Professor Larbalestier and others here will mean, for example, that the Superconducting Supercollider can be made much smaller and more cost effective than with earlier conductors.



*Football, fans, and the Engineering Research Building as seen from Camp Randall.*

Another facility in our Engineering Research Building is the Materials Science Center, where we have one of the nation's best collections of equipment for materials characterization and analysis.

Successful manufacturing demands design that is imaginative and conceived with a life-cycle perspective. Beginning in fall 1987, students in mechanical engineering design courses have a brand new Computer-Aided Design Laboratory (CADLAB) for creating engineering designs on computers. State of Wisconsin money designated for undergraduate laboratory improvement funded this beautiful state-of the-art lab in the Mechanical Engineering Building. Professor Wayne Milestone of mechanical engineering and others in the college developed this facility, which seats 24 students at 12 personal computers linked to the instructor's computer and a projector. Printers and plotters provide hard-copy output, and the design information can be sent by wire to our new computer-integrated manufacturing facility in another part of the building.

This laboratory builds on the technology used in the writing and engineering drawing computer laboratories developed in general engineering by Professor James McNeary, which were featured in last year's annual report. The graphics software used by freshmen in their drafting and graphics courses carries over into the CADLAB.

Our Department of Industrial Engineering, also located in the Mechanical Engineering Building, is traditionally strong in industrial statistics. We suffered a loss in that area this past year with the death of Professor William Hunter. The Center for Quality and Productivity Improvement, which he helped found, is carrying on this important work under the direction of Professor George Box.

Professor Gregg Vanderheiden of industrial engineering is director of the UW-Madison TRACE Center, which is located in the Waisman Center on Mental Retardation and Human Development near University Hospital and Clinics. He and colleagues have developed a system that a severely handicapped person can use to completely control a personal computer. With a "sip and puff" tube and a special interface card, the person can send Morse code instructions to a computer and gain full access to all the software written for it.

The TRACE Center is designated by the National Institute of Disability and REhabilitation Research as the national center for computer access by disable persons.

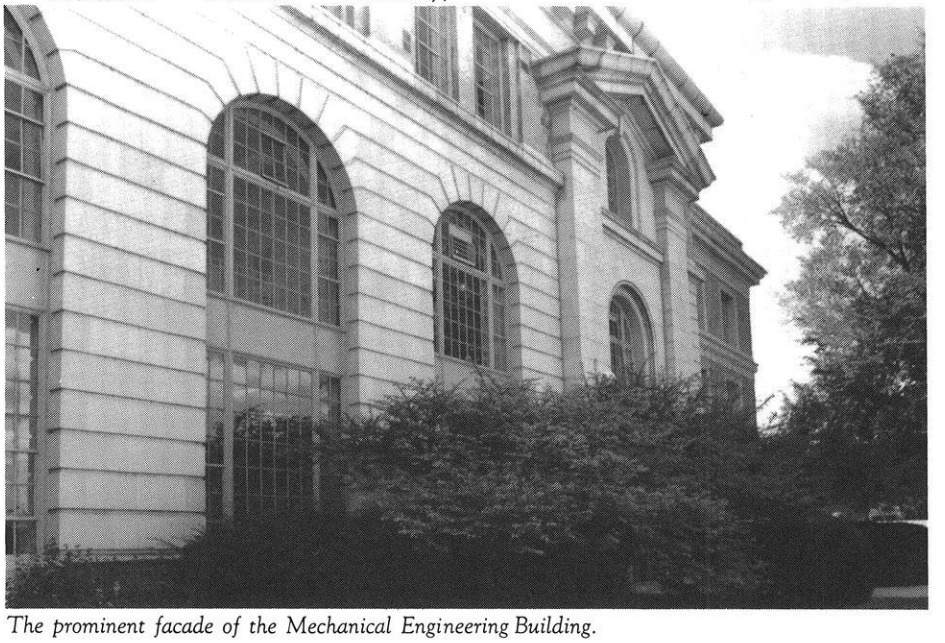
Also at the Waisman Center, Professor Paul Milenkovic of our Electrical and Computer Engineering Department can observe the use of a mouth sonar instrument he developed. This device identifies vocal tract disorders stemming from certain types of head injuries and other neaurogenic disorders.

Voice checkups using tradtional methods can be so traumatic that patients avoid them. Professor

Milenkovic's device simply bounces sound waves off the vocal organs while the patient makes common vowel sounds. A desktop computer interprets sonar echoes to analyze the shape of the vocal tract.

Back on our campus, in the Engineering Building, other electrical and computer engineers have developed one of the nation's best programs in power electronics. Modern electronic circuitry can provide both energy savings and greatly improved control of electric motors in such applications as machine tool drives, robotics, equipment that handles liquids and gases, and consumer appliances and tools.

Professors Donald Novotny, Thomas Lipo, Deepakraj Divan, and their colleagues have had an outstanding program in this area for many years, developing new technology and educating students. This past year they organized a Power Electronics Research Center, which reflects the growing activity in this area.



*The prominent facade of the Mechanical Engineering Building.*

In another part of the Engineering Building, a million-pound universal testing machine took on a sample of 50-year old concrete. In the college's longest-running experiment, Emeritus Professors George Washa and Jesse Saemann, engineering mechanics, and Professor Steven Cramer, civil and environmental engineering, crushed sample cylinders. Other samples poured in 1910 and 1923 will be tested at 100 years.

I have already shown you many of our students and described the work of others. I would like to tell you a little about undergraduate activities outside the classroom.

A big event for the college this past year was our biennial Engineering Expo, a tremendous success that drew 15,000 visitors to see student exhibits on the latest in technology. One of the stars of Expo was Little Oscar, a robot that prepared and served hot dogs. Little Oscar was great fun and demonstrated not only robotics, but also the fact that our college's cooperation with industry is so well-established that it extends regularly to undergraduates.

The college also has many services for students. The Pre-Engineering Office provides information to high school students and advises all pre-engineering students (those who have not entered a degree-granting program). Students in degree programs have advisors in their major departments.

A Minority Engineering Program in the college provides advising, tutoring, and financial assistance. Student organizations for minorities and women include the Wisconsin Black Engineering Student Society, the Hispanic Organization for Pre-Professional Engineers, and the Society of Women Engineers, which promotes professional development, encourages interaction among women engineering students, and is a resource for female high school students interested in engineering.

The college has several other honorary, professional, and social organizations which help students learn engineering through meetings and field trips. The Polygon Engineering Coucil is composed of representatives from all the student societies.

These societies also let students demonstrate their knowledge of engineering. The Society of Automotive Engineers (SAE), for example, compete in the Mini-Baja, an annual competition where students design, build, and run off-road vehicles. At the 1987 Midwest event our team took second place, just a point short of winning.

Another student activity is the Wisconsin Engineer, a magazine our students publish. Twenty-five or more students each semester gain experience in communication and publish valuable news about the college—and I'm not just saying that because I was associate editor in my student days here.

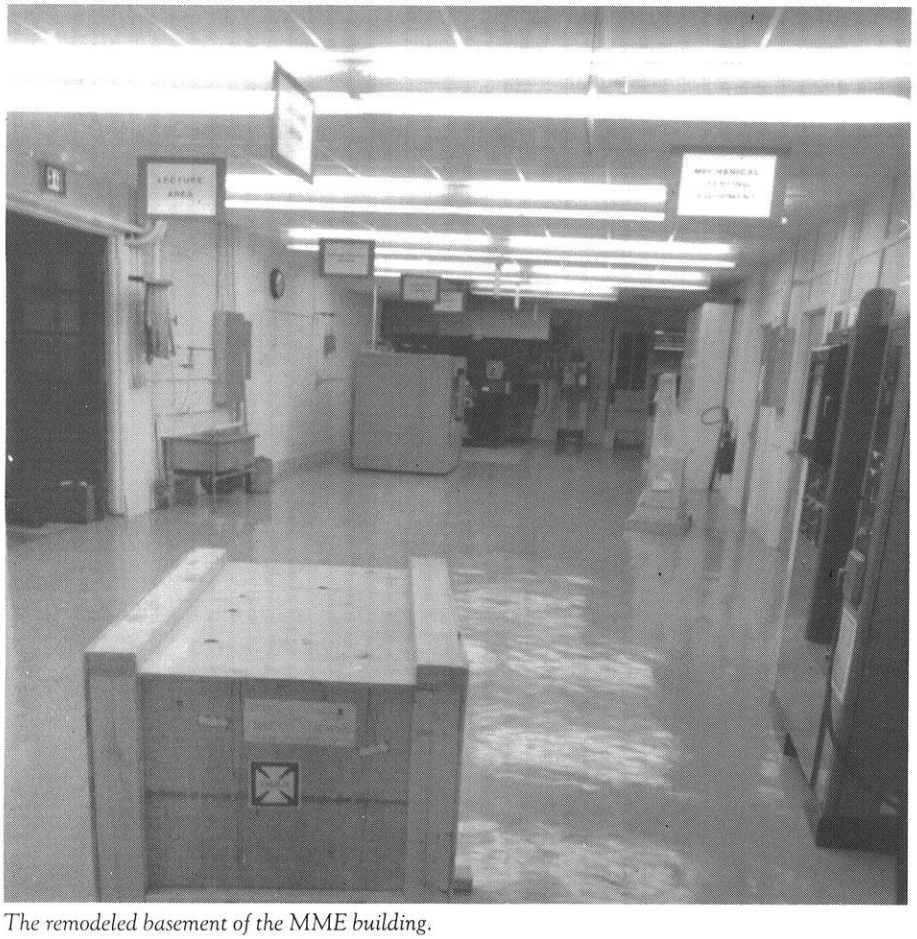
To end our tour, we arrive back near the site of the new addition to the Engineering Building. In the east wing of the existing building, the Engineering Placement Office is undergoing some major changes. Professor James Marks, general engineering, retired this year after 31 years of service to the college as placement director. We have changed the office name to Engineering Career Planning and Placement, and I have appointed Sandra Arnn, formerly director of cooperative education, as director of the overall program.

Ms. Arnn and her staff are developing new ways to serve both students and employers. Our goal is to help students with career planning throughout their college years. Tehy can participate in co-op education and summer internships, talk with recruiters at job fairs, and interview for permanent employment.

Our greatest accomplishment as a college is to send well-educated engineers out to careers that are satisfying for them and productive for our state, nation, and world. With the quality of faculty, staff, and students we have, and with the kind of progress they made during this year, I am fully confident we will continue our tradition as a leading educator of outstanding engineers.□

John G. Bollinger

# A New Look for MME Lab



*The remodeled basement of the MME building.*

**By Paul J. Gassere**

The Metallurgical and Mineral Engineering building on University Avenue is one of the oldest structures on the engineering campus. It has been expanded, remodeled, rewired and refitted countless times in the continual quest to keep pace with the evolution of technology and the materials needed to transform the designs of engineers into functional devices.

While the undergraduate curriculum of the Metallurgical and Mineral Engineering department remains based on subjects applicable to iron and nonferrous metals, course material dealing with ceramics, electronic materials , superconductors and hybrids like metal-matrix composites is continually being added to the program. The concept of materials in general and metals in particular is the nature of the current changes being made and those planned for the future.

## LAB REMODELING

Over the summer, the first floor lab area was cleaned out, painted, fitted with a suspended acoustic tile ceiling and finished with tile flooring. Obsolete equipment was hauled out —literally by the ton— and the remaining rolling mill and heat treatment facilities relocated to make room for new apparatus scheduled for installation in the coming months.

The white walls and ceiling were a shock to some students returning from summer vacation. The previous decor consisted of a bare concrete floor and a collection of pipes, conduits and dust that could best be described as "Early Industrial Revolution."

## ULTRA-RAPID QUENCHING

Made by Edmund Buhler GmbH of West Germany, this device consists of a radio frequency inductive melting unit and an injection system that releases a measured amount of molten metal into a cylinder. The "splat" is created by rapid compression between two opposing pistons or a piston and stationary anvil held at low temperature. What results is a sample 10 to 30 millimeters in diameter with a thickness ranging from 10 to 100 micrometers. Cooling rates in excess of a million degrees per second ( °K/sec) are claimed by the manufacturer. The system operates in a vacuum chamber held at or below mbar by means of mechanical and turbo-molecular pumps. Atmospheres of argon, helium, nitrogen, hydrogen or air can also be introduced.

This machine induces virtually instantaneous solidification of liquid metal. Rapid or ultra-rapid solidification can produce meta-stable phases and is used in the study of micro-crystalline and amorphous (non-crystalline) metals.

*Ultra–rapid quenching can suppress transformations that normally occur when metals are cooled slowly or quenched conventially.*

Ultra-rapid quenching can suppress transformations that normally occur when metals are cooled slowly or quenched conventionally. Micro-structural changes that involve solid state diffusion can be stopped in their tracks at elevated temperatures and "snapshots" studied at room temperature.

## VACUUM MELTING

A Vacuum Industries Inc. System

VII (tm) metallurgical vacuum melting chamber is the central module of a system adaptable for melting, heat treatment, welding, sintering, brazing or quenching in a high vacuum or inert gas environment. The chamber is made of stainless steel and has a vacuum system similar to that of the ultra-rapid quenching unit. Melting is done by electric induction, with power provided by a 9600Hz Inductotherm Power-Trak (tm) supply rated at 15 kW. Among the optional accessories included in this system is an internal "windshield wiper" for the sightglass to remove any spatter that might block the view of the crucible.

This type of chamber is essential for work with metals tending to form undesirable surface films or prone to contamination by gasses present in air. Vacuum melting and refining are used commercially for de-gassing molten metals like high strength steels or aluminum alloys that would otherwise be subject to porosity, embrittlement or excessive crack-starting inclusions. Fusion welding and the sintering of compacted powder metal or ceramic materials also works well under vacuum.

## MECHANICAL TESTING

The new MTS (Instron) tensile tester is a table-top version of the familiar Instron machine. This updated and down-sized unit is equipped with digital readouts and is capable of direct connection to a computer for data recording.

*The real significance of the new hardware is that it will provide accessability of research grade equipment, enabling undergraduate students to do state-of-the-art research.*

## HIGH TEMPERATURE TUBE FURNACE

A tube furnace consists of a refractory tube roughly 2 to 3 inches inside diameter and 3 to 4 feet long surrounded by electric heating elements and lots of insulation. The important features of the new Deltech (tm) unit include sustained temperature capability of over 1700° C and true atmospheric control. True atmospheric control means that the partial pressure of gas species that might react with the sample material at working temperature, e.g. oxygen with most metals, can be specified and maintained at a known level. This type of control is obtained by pumping in a mixture of gasses formulated to yield the desired product species and partial pressure when they react and equilibrate at the working temperature and pressure. An advantage of this system over those providing only vacuum or inert gas shielding is that it allows the selection of an oxidizing or reducing environment and control of reaction rates.

## INTENDED FOR TEACHING

This equipment is being installed in the general heat treatment lab area -room 103A- and is meant for use by classes or individual students working on projects or experiments requiring the special capabilities of the new machinery.

According to Professor Reid Cooper, MME instructor and ceramics specialist, the installation of this equipment and the redesign of the heat-treatment lab was done to give the department more versatile capabilities in mechanical testing, high temperature operations and rapid solidification. He added that the real significance of the new hardware is that it will provide "Accessibility of research-grade equipment... so (undergraduate) students can do state-of-the-art work."

The remodeled lab and the new equipment will be available for use by everyone from freshmen to doctoral candidates , but undergraduate lab classes and seniors doing independent lab work for their design project classes are expected to be the major users.□

# WCAM Aids Faculty in Integrated Circuit Research


*The Highway Lab, site of the new ECE lab.*

**By Martha Larson**

To the average undergraduate engineering student, the diagram of the ideal electronic circuit in the **Microelectronic Circuits** text bears only vague and rather incomplete resemblance to the actual integrated circuit chip manufactured by industry. Most students are aware that an appreciable number of steps are missing between the circuit diagram on the blackboard and the functioning device that is able to operate according to commercial or government specifications. What many do not realize, however, is that the role that the University plays in the development of integrated circuit (IC) chips does not stop with the circuit diagrams studied in undergraduate courses.

*The role the University plays in the development of integrated circuit chips does not stop with the circuit diagrams studied in undergraduate courses.*

In addition to teaching, professors are also researchers who devote much time and attention to research and development projects in the laboratory. The Wisconsin Center for Applied Microelectronics is an example of a University laboratory which bridges the gap between theoretical possibilities and the functioning physical devices.

The Wisconsin Center for Applied Microelectronics (W.C.A.M.), located in the Highway Lab across from the Engineering building, was founded and is currently directed by Electrical Engineering Prof. Henry Guckel. It is unique in that not only does it conduct research on state-of-the-art microelectronics, but it also has the capacity to fabricate industrial-quality circuits and sensors. The Center receives its funding from the University as well as from industry and government, both state and federal. Recently remodeled, its advanced equipment and modern facilities make the design, testing and fabrication of integrated circuit chips possible at the University itself.

In addition to fabricating IC's, the W.C.A.M. also emphasizes the design and manufacture of sensors as well as research on new materials to be incorporated into IC's. A sensor is an electronic device that is sensitive to external stimulation. This stimulation could be chemical, mechanical, or optical; more specifically, a sensor might detect humidity, pressure, or light. The W.C.A.M. is particularly interested in the so-called "smart sensors," devices which incorporate sensor, driving circuitry and output circuitry on a single

*ECE Professor Denice Denton*

chip. At this time, techniques are being developed by which three-dimensional chips can be produced. Three dimensional integration allows chips to be expanded without an increase in surface area. This entails the stacking of layers of circuitry, one on top of the other. For example, in a smart sensor, the top layer may contain an optical detector. This detector generates a signal which is then converted by the analog to digital convertor in the middle layer. The bottom layer contains circuits for memory and microprocessing. There are many difficulties that must be resolved before such a configuration is possible.

Professor Denice Denton in the Department of Electrical and Computer Engineering is presently doing polymer research in the W.C.A.M. that will not only benefit integrated circuit technology, especially three-dimensional integration techniques, but will also be applicable to sensor development. At this time she is specifically interested in a polymer called polyimide and her efforts are concentrated on characterizing the substance and researching its potential applications. The insulating material normally used in integrated circuit chips is silicon dioxide, but the application of this substance to the wafer can be a time-consuming process requiring high temperatures (1000 degrees Celsius). A polymer which can be spun onto a wafer and then cooked at a relatively low temperature (400 degrees Celsius) is potentially more efficient. Such a polymer can also aid progress towards finer and more uniform etching. With such a substance, the necessity of wet chemical processing, a cause of irregularity, is eliminated. The polymer is also amenable to plasma etching, the process used to inscribe the tiniest possible lines in the device surface. Polyimide can be used in three-dimensional integration in order to smooth over the surface of a chip made uneven by the large number of mask steps needed to make chips with multiple active layers. A smooth surface insures continuity in the conductive layers of the chip, since even a small break in such a layer will cause malfunction.

*If the permittivity of polyimide varies predictably with moisture content, it would be the perfect material to use in a humidity sensor.*

According to Professor Denton, however, polyimide has a significant drawback, namely that it absorbs water. This absorption changes the dielectric permittivity of the chip, which can be the major source of unreliability. Nevertheless, she remains optimistic and asserts that this drawback is a potential advantage. In other applications, if the permittivity of polyimide varies predictably with moisture content, it would be the perfect material to use in a humidity sensor. Once such a sensor is designed, however, her work is far from finished. She must then test it to determine its long-term reliability and its reaction to other environmental factors such as smoke and acid rain.

*WCAM pursues the necessary research and development that carries an idea off of the paper and into a functioning physical device.*

It is clear that Professor Denton's contributions to the advancement of microelectronic technology does not stop when the bell rings and the students file out of her Electronic Devices lecture. Since the University plays such a broad role in technological research and development, her work continues far outside the classroom. It is the responsibility of laboratories such as the Wisconsin Center for Applied Microelectronics to pursue the necessary research and development that carries an idea off of the paper into a functioning physical device.□

# Arnn Takes Over as Placement Office Director

**By Lisa Russell**

Sandra Arnn is the new director of the Placement Office, currently renamed the Office of Career Planning and Placement. Ms. Arnn received her undergraduate degree in French and Sociology from UW–Madison, although she also studied at Barnard College. She continued her education at UW–Madison where she received an M.S.S.W. degree.

*Sandra Arnn not only brings a wealth of experience to her new job but also a lot of enthusiasm and ideas.*

After college, she worked as a professional social worker in different settings and with varying duties. Five years ago, she came to the College of Engineering as a counselor, and in April of 1985 she became the first full-time Cooperative Education Director. Ms. Arnn has been the Director of the Career Planning and Placement Office since July 1, 1987, and Helen Richardson is the new Assistant Director.

Sandra Arnn not only brings a wealth of experience to her new job but also a lot of enthusiasm and ideas. She has already begun renovating both the office area and the interviewing rooms to make interviewing more pleasant for both students and recruiters. As Placement Director, she is responsible for overseeing the Cooperative Education Office, which has also recently named a new Director, Marion Beachley. Coordination between the two offices should increase, providing students even easier access to career information.

Last year, many large companies decreased the number of students that they hired nation-wide; therefore, one of Ms. Arnn's goals is to increase the number of companies that interview on campus. Additional interview space will be needed as the number of companies increases. A computer system is needed as the office is still using typewriters and file cabinets to process and store its information.

*Sandra Arnn is the new placement director*

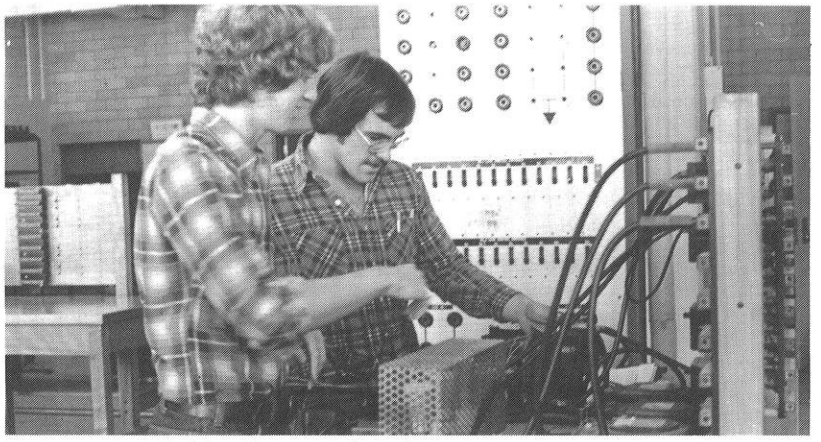
The Career Planning and Placement Office is not just for seniors. All engineering students are encouraged to use the office as a resource to help make informed career decisions. Undergraduates can look forward to an expanded schedule of workshops about career decisions, values, interviewing and resumes, and graduate school. Graduate students can also use the Office as a resource, and better ways to serve graduate students are currently being developed. Foreign students can find information about which companies will allow them to start work in the United States and then transfer to a foreign subsidiary in their own country. Even alumni can benefit from bi-monthly job bulletins which contain names of employers looking for engineers with experience. Students can peruse the promotional literature of over 800 companies and governmental organizations, but can also find literature written by critics of various employers. There is enough helpful information for anyone in engineering to gain by utilizing the Career Planning and Placement Office.

One of Ms. Arnn's more hectic jobs is sometimes simply seeing that the interview process runs smoothly. Recently, the CIA interviewed on the engineering campus. Ms. Arnn stated that the CIA, like any other employer, would continue to conduct interviews here as long as students want to interview with them. She also believes that students who do not agree that the CIA should be allowed on campus should be allowed to express that opinion; however, any protests must be orderly so the protestors do not interfere with the rights of the students who want to interview. The engineering campus receives an enormous amount of campus publicity when the CIA interviews, on the erroneous assumption that the majority of students interviewing with the CIA are Engineering students. Most, however, are Letters and Science students. Letters and Sciences majors can sometimes interview with companies on the engineering campus if there are any openings after the engineering students have registered to interview.

*Undergraduates can look forward to an expanded schedule of workshops about career decisions, values, and graduate school.*

The Career Planning and Placement Office has a lot to offer everyone, so visit them today!□

# Safety First! Helpful Hints for Lab Users



*Using caution in the lab will minimize hazards.*

**By James F. Ulrich**

"One false move and you're dead."

This phrase sounds like a line from a TV cop show, but it could well be used to describe the situation in an electrical engineering laboratory. The potentially lethal voltages and currents present in any such laboratory, in the academic or the working world, require all electrical engineers to know and use many common safely procedures if they are going to avoid that one false move.

In addition to the common safety practices listed below, it is important to remember that every lab has its own particular dangers that have to be considered on an individual basis. A safe working environment cannot be achieved by following a specified number of specific procedures, but only by a persistent effort on the part of engineers to make their work place a safe one. Safety is not a three-pronged plug or an isolation transformer, but an attitude. A safety conscious attitude will guide engineers along the path to a safe working environment by driving them to find out about both the common hazards present in all labs as well as the particular ones present only in their own. Listed here are some important practices that every safety conscious electrical engineer will know and follow at all times in every laboratory:

1. Don't wear metal jewelry. A metal watch or ring, if it should short circuit two points in a high power piece of equipment, can carry enough current to heat up and burn off a finger or hand. A metal chain around the neck can help complete a circuit through an engineer and ground, resulting in a possible electrocution. In addition, any jewelry can get caught in moving machinery and the helpless engineer could lose an arm or leg or even his life. (This is also a reason not to wear loose fitting clothes in a lab.)

2. Use one hand when reaching into a piece of equipment with power applied to it. On those occasions when a scope probe or voltmeter must be attached to a live piece of equipment, one hand is used to do the attaching and the other goes in a back pocket or at the very least, behind the back. It is very difficult for a current path to be completed through a body if only one hand is touching the circuit. Even if a path is completed through ground, the current must flow through the arm, side and leg, avoiding the heart and minimizing the chances of a serious catastrophe. With both hands in the circuit, however, a slip can much more easily cause a current path to be completed through the body and especially through the heart.

3. Never work alone in the lab. As in swimming, the buddy system is vital to lab safety. If there is trouble in a lab, the chances of survival are greatly increased if someone else is there to call an ambulance.

4. Whenever possible, use an isolation transformer to power equipment being tested. This helps prevent voltage from being developed between the engineer and ground. Combined with using only one hand to prevent the establishment of a current path, an isolation transformer greatly diminishes the chances of an electrocution.

5. Don't use cheater plugs. Three-prong, grounded plugs are a safety feature required on new equipment to prevent ground loops from shocking a person who touches two different pieces of equipment at once. Bypassing this feature by using an adaptor for two-prong outlets invites disaster.

6. Plan your work. Whenever possible, equipment should be arranged so that the engineer is not even exposed to high voltage lines except when making measurements.

7. Learn where the lab's safety equipment is and how to use it. Every lab should have a cane for removing an electrocuted victim from a live circuit and a fire extinguisher for use on electrical fires. An extinguisher is useable on electrical fires only if it has a blue circle on it inscribed with the letter "C".

8. Learn CPR. Electrocution can result in cardiac arrest which need not be fatal if someone in the lab can perform CPR.

The above points are not a complete list of safety procedures, nor could any such list ever be completed. Even if it were possible to list all the common hazards, the particular ones present in specific labs would still far outnumber the common ones listed. Only with a persistent safety consciousness, as well as a knowledge of the common sense rules, can an engineer hope to avoid making the one false move that leads to disaster.□

# Engineering Briefs

By Craig Bahr

### Civil and Environmental Engineering

The UW-Madison Civil and Environmental Engineering Department, in cooperation with the Forest Products Laboratory and industry, is becoming known as a leader in research in the field of engineered wood products.

Vast amounts of wood are available for use provided care is taken when timber is cut down. Since Mother Nature is in control of the physical characteristics of natural wood, research is being done to improve production techniques for lumber. Current research uses electrical and optical scanners to collect data which in turn can be used to improve wood production processes.

The research is being used to study light frame trussed roof systems and wood bridge design. The use of three-dimensional computer models accounts for previously unrecognized effects of load sharing. The Wood Structure Product Research Program continues to grow and emphasizes the national need to use our timber resources more efficiently.

### Chemical Engineering

President Reagan presented a National Medal of Science to R. Byron Bird, UW-Madison professor of chemical engineering, for his work with plastics theory and the Japanese and Dutch languages.

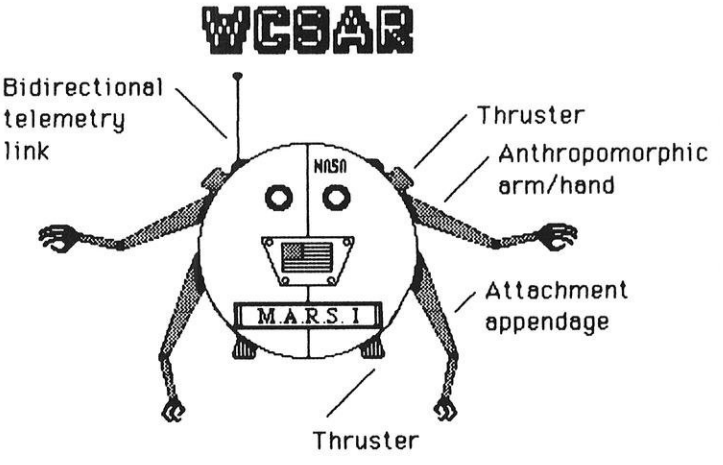
Reagan called all of the twenty winners of the medal "the heroes of the modern age." He added that Bird received the medal for his research in the area of polymer kinetics which is important in the manufacture of new high-performance materials. The publication of Bird's book in 1960 about transport phenomena started a revolution in the field of chemical engineering.

Bird, a UW professor since 1953, was the student of chemist Joseph Hirschfelder who won the award in 1976. Bird claimed "This is the nicest thing that's ever been done for me." He is the author of thirteen books and almost 200 scientific papers. His other awards include Fulbright and Guggenheim fellowships. In 1969 he was elected to membership in The National Academy of Engineering.

## Electrical and Computer Engineering

Professors John G. Webster and Willis J. Tompkins of the UW-Madison Electrical and Computer Engineering department, along with the Wisconsin Center for Space Automation and Robotics (WCSAR), are developing a space robot to aid astronauts.

In this system, the robot would provide an extra set of hands for astronauts and would be sensitive to different types of touch. An astronaut would perceive pressure from the robot's fingers, giving him the ability to feel digits through the robot. This would enable the astronaut to remain in a space station and would minimize the astronaut's time in space. When completed, the robot will help astronauts significantly in space technology.




Wisconsin Engineer

## Nuclear Engineering

Professor John Conrad of the UW–Madison Nuclear Engineering Department has developed a technique to harden surfaces. The technique, using plasma source ion implantation, has the potential to be quite revolutionary. Plasma source ion implantation has been shown to be a very effective process for improving the corrosion and wear resistance of materials. Patents are pending on this new technique which is considerably more desirable than existing methods.

# Engineering Education Abroad

# Complementing a Technical Education

**Special from the International Engineering Programming Office.**

*Students find out the particulars of the program.*

**Cynthia Mann** (Germany): "Challenging—an opportunity to see what is in the outside world and to see if I could cope with it."

**Michael Brown** (Scotland): "The Scots are really a friendly lot. I made many friends, and I hope to go back to see them in the future."

**Patrick Nugent** (Poland): "I am glad I had the experience; I would do it all over again."

**John Moore**(Germany): "It was an experience I will always consider valuable for many reasons."

**Jay Tomlinson** (France): "Marvelous; beyond all my expectations."

**Don Gaymon** (Germany): "Very positive experience, great personal growth."

**Carol Cafferty** (Germany): "Last year was one of the best years I have had in my life."

The above statements are representative of the comments made by most of the Engineering College's students who have returned from a foreign study or work experience. If you, too, would like to have a foreign training period as a part of your education, some fundamental requirements must be met. The student must be in good academic standing in the College (a "B" or better G.P.A.), must have completed the "core" courses in his/her departmental degree requirements, and must demonstrate competence in the language of the country, usually by the successful completion of a second year college level language course. Those students accepting summer job offers must also demonstrate language competence for specific countries.

There are two college programs which require intensive preparation. The UW Japanese Engineering Leadership Program is a competitive program available to those students who wish to study the Japanese language and culture, culminating with a year of study and work in Japan. The new Certificate in Japanese Studies for engineering majors is another opportunity for students who wish to study the Japanese language. Students in this program may spend a year in Japan as well. The requirements of both of these Japanese programs are taken concurrently with the students' departmental requirements. Professor Edward Daub heads the Certificate program and can provide specific information about it.

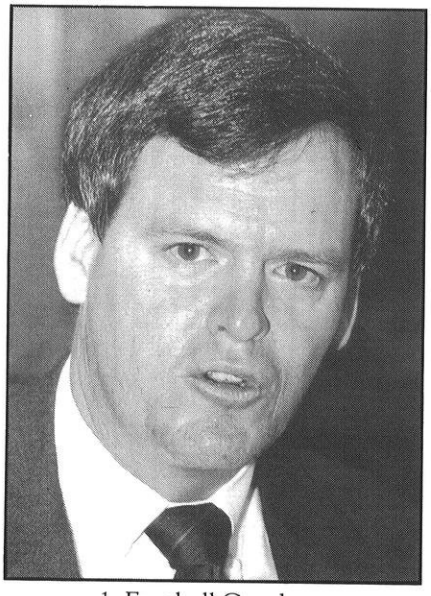
*Students have also told us that the addition of a study or work abroad period to their UW training has proven to be a real benefit when industrial representatives arrive on campus to begin job interviews.*

Students in academic foreign programs progress toward their degrees by the transfer of credit from the foreign institution to their UW academic tran-

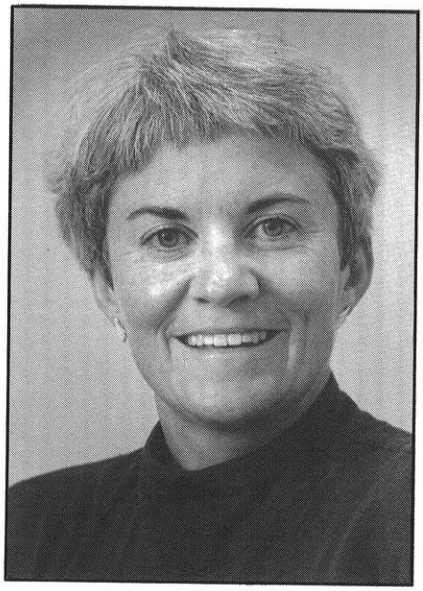
**Continued on page 21.**

# People You

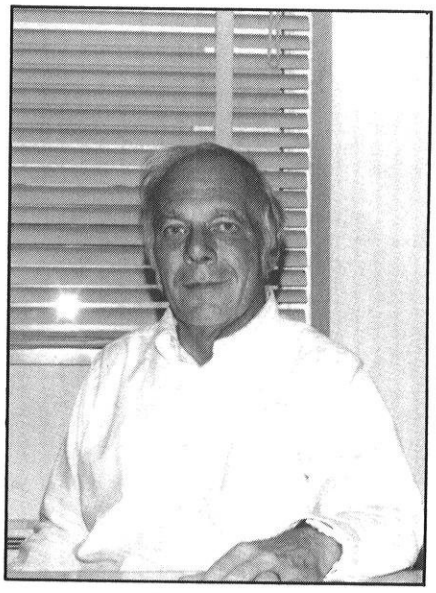
Below are the pictures of some of the many important figures on campus. If you are a new student in engineering, here is your chance to become familiar with these



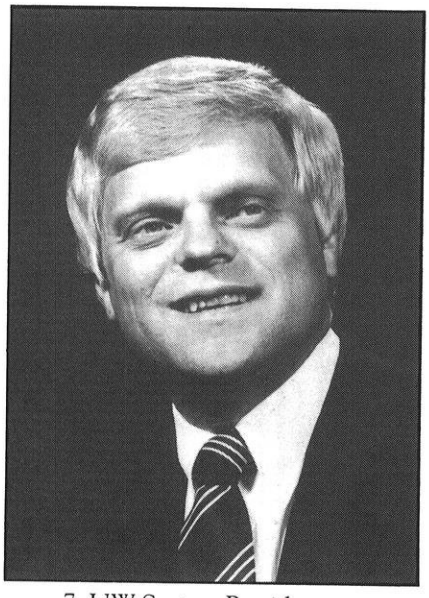
1. Football Coach



2. Dean of Students

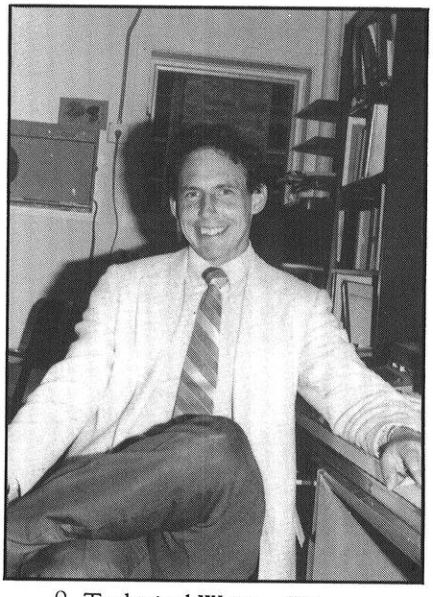


3. CEE Chairman



7. UW System President

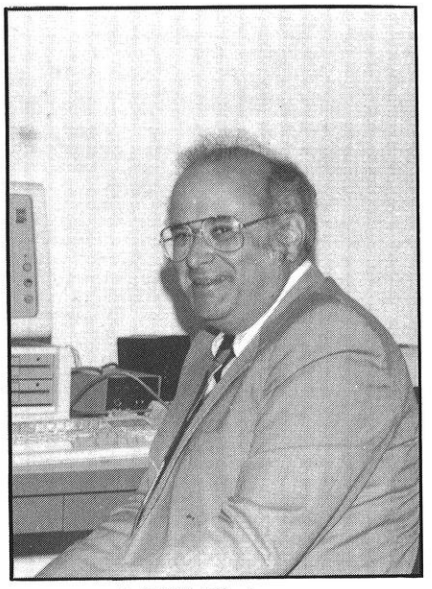
8. Chancellor



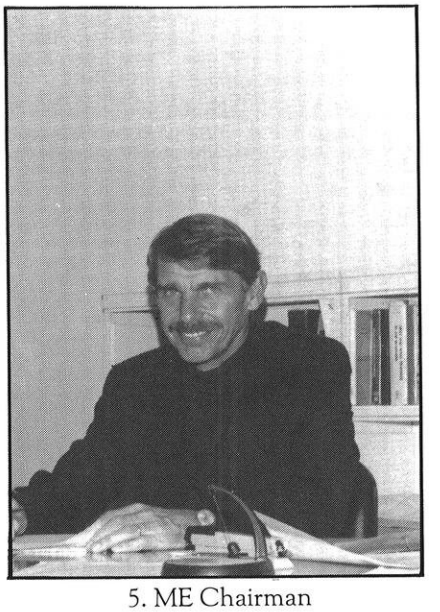
9. Technical Writing Director

# Should Know

People. If you are an upperclassperson, test your knowledge and see how many you know. Answers appear on page 23.

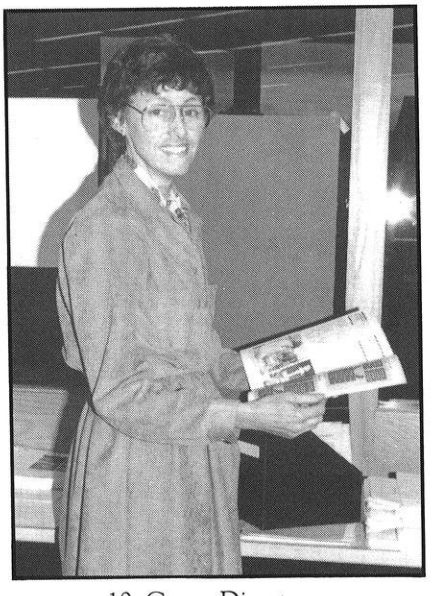


4. ECE Chairman

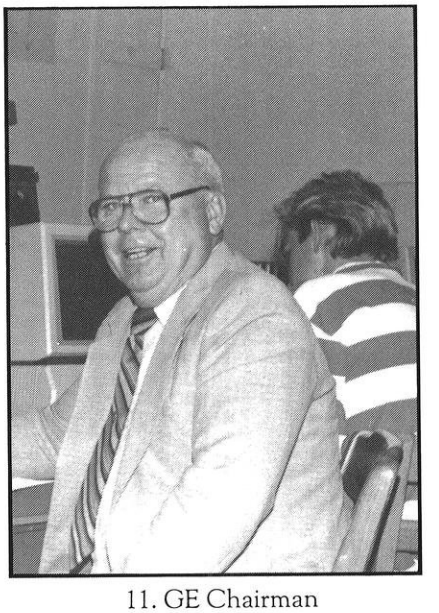


5. ME Chairman

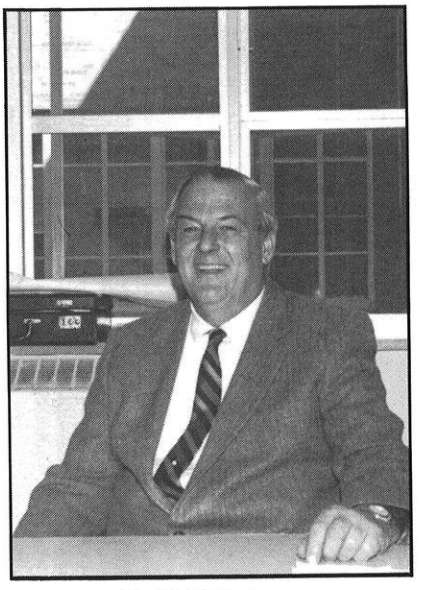
6. Dean of Engineering



10. Co-op Director



11. GE Chairman



12. EM Chairman

# Are Engineers Culturally Illiterate?

Educators have found that a sure way to get headline space is to conduct a poll that shows how ignorant Americans are. Recent surveys have shown that American students don't know when the Civil War was, and don't have any idea who Stalin and Churchill were.

None of this should be surprising. The great educator G. Marx showed years ago that Americans have trouble figuring out who's buried in Grant's tomb.

But the headlines continue. Most recently, E.D. Hirsch, an English professor at the University of Virginia, has made a splash by publicizing the "cultural illiteracy" of Americans. In a recent People magazine article, he claims that "Cultural literacy is the key to economic and democratic strength in this country... The Japanese workers are so effective, in part, because they share a background of information with every other worker and communication is easy and effective."

What about the cultural literacy of engineering students at UW—Madison? Fifty juniors and seniors took a short version of Professor Hirsch's cultural literacy quiz that appeared in People magazine.

The results? More amusing than alarming. UW engineering students showed some confusion, but mostly they showed adequate literacy combined with a zany sense of humor west of Randall and south of University. Maybe UW engineering students should develop a "Sense of Humor" index to be used to debunk bombastic academics such as Professor Hirsch.

Below are some of Hirsch's cultural literacy test words and some of the engineering student answers. The real answers (from People magazine, Aug. 10, 1987) appear on page 23.

| | |
|---|---|
| 1. 1776 | a musical about the American Revolution |
| 2. amicus curiae | butterfly; a friend in briefs; poison on darts |
| 3. auf Widersehen | German beer |
| 4. balance of payments | remainder due; what they owe us (or U.S.). |
| 5. Bolshevik | male ballet dancer "en pointe" |
| 6. carbon—14 dating | going out with your anthro professor |
| 7. dramatis personae | very dramatic person |
| 8. Elementary, my dear Watson | what Crick said (about DNA, I think) |
| 9. extraterrestrial | Californian |
| 10. The id | a comic strip; women's clothing store |
| 11. isotope | lines of equal tope |
| 12. Fabian tactics | stealing—as in "Oliver" |
| 13. jargon | a term for terms; what my thesis is full of |
| 14. kosher | perfect or great, as in pickles |
| 15. leprosy | "Face off in the corner" |
| 16. man Friday | Sergeant Joe |
| 17. oeuvre | French for "snack" |
| 18. protagonist | who starts the fight; one who puts things off |
| 19. quark | slight imperfection |
| 20. rigor mortis | stage of being dead |
| 21. SEC | as in "just a sec"; Southeastern Conference |
| 22. wampum | "...stompum, kick 'em in the knee..." |
| 23. Wounded Knee | what you get from wampum |
| 24. yin/yang | two panda bears |
| 25. Elizabethan drama | boring |

*Compiled by WE staff*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# The New Mini-PC's Down-sizing for Convenience

**By Elise Lind**

A computer you can take on a road trip? How about just to the library? This year's new size in microcomputers is the laptop; it is small enough to go anywhere, and light enough for anyone to carry. Computer lovers need never be without their little lunchbox-sized PC's.

In this age of "smaller is better," some manufacturers estimate that one of every ten PC's sold this year will be a laptop. A laptop has many of the standard features of a desktop computer, and when hooked up to a standard monitor serves that purpose well. But this PC's best quality is its portability. Charge up the battery and go.

## FEATURES

"Laptop" is a general name used for computers in a few different classes of size, weight, and performance. The most popular are the "clamshell" models. When closed, a machine of this type is about one square foot and weighs 10 to 15 pounds. The top flips up to reveal a small monitor that holds as much data as a desktop PC's, and a small keyboard with full-sized keys. Most models offer monitors with either a "low-glare" LCD display (like a calculator display) or a backlit screen.

*The laptop market is definitely hampered by President Reagan's recently-imposed 100 percent tariff. The tariff is in retaliation to Japan's allegedly unfair microchip pricing.*

Smaller, less expensive laptops have less random access memory (RAM) than comparable desktop computers, but all may be expanded to approach full-size capacity. The microprocessor (the "brain") in laptops also tends to be slower than in a desktop. Most models are fully IBM-compatible, and come equipped with a Diskette Operating System (DOS) version. All use 3.5-inch floppy disks.

Battery life for a laptop may be anywhere from four to ten hours, depending on the size of the model and the amount of disk drive use. Standard equipment includes an AC adaptor, and most models have an optional "automobile adaptor" to plug into a car's cigarette lighter.

Higher-priced versions in this category might also include standard features like hard disk drives, backlit screens, back-up batteries, and speed selection to conserve power.

In a different category are the laptops of the slightly larger and heavier "lunchbox" size. These computers are generally faster, more expandable, and use 5.25-inch floppy disks and hard disks. Not all are battery-operated; some are AC-only.

*In this age of "smaller is better," some manufacturers estimate that one out of every ten PC's sold this year will be a laptop.*

The most expensive class of laptop PC's are more aptly referred to as

IBM

*Portability allows laptops to be used almost anywhere.*

"luggables," and are about the size of a portable sewing machine (15 to 20 pounds). These models are very close to and in some ways interchangeable with desktop computers. Most do not have batteries, making them considerably less portable.

## AVAILABILITY

The laptop market is definitely hampered by President Reagan's recently-imposed 100 percent tariff. The tariff is in retaliation to Japan's allegedly unfair microchip pricing. It covers all Japanese hand power tools, some sizes of color TV sets, and most laptop and desktop computers. The 100 percent tariff is on the imported value, or about one-half of the list price, raising the final cost by 50 percent.

*This year's new size in microcomputers is the laptop; it is small enough to go anywhere, and light enough for anyone to carry.*

Brian Doyle, Systems Consultant for CBM Computer Center, Inc., says those tariffs have already affected sales for companies like Sharp, Toshiba and NEC. He added that a recent government ban on Toshiba imports will limit sales of those models to equipment already in the U.S.

The most popular brands in Madison area computer stores seem to be IBM, NEC, Sharp, Toshiba and Zenith. Doyle says the Sharp laptops are his hottest sellers, and that he sometimes has trouble filling all of the orders. Joe Kieta, Computerland of Madison Account Executive, claims that availability is not a problem for him, but does admit that Toshiba laptops are "slightly harder to get." His most popular models are NEC and Zenith.

*Feature for feature, laptop PC's are more expensive than desktop computers— you pay for portability.*

Feature for feature, laptop PC's are more expensive than desktop computers—you pay for portability. But that portable size would also be a plus in a dorm room. You may not need a computer you can take on a road trip or through airports, but if you are in the market for a PC and like the thought of being able to use it anywhere you like, you may want to take a closer look at laptops. □

SOME COMPARISONS

| Model | Microprocessor No. | speed | RAM min | max | Standard disk drives | Standard soft—ware | Base price |
|---|---|---|---|---|---|---|---|
| LAPTOP | | | | | | | |
| IBM PC Convertible | 8088 | 4.77 MHz | 256K | 512k | 2-3.5" | applica—tions (no DOS) | $1695 |
| Datavue Spark | 8088 | 4.77/ 9.54 MHz | 384k | 640k | 1-3.5" | DOS | $995 |
| NEC Multispeed | 8086 | 4.77/ 9.54 MHz | 640k | 640k | 2-3.5" | DOS, applica—tions | $1995 |
| DESKTOP | | | | | | | |
| Zenith EaZy PC | 8088 | 7.16 MHz | 512k | 640k | 1-3.5" | DOS, Basic | $599 |
| IBM Personal System/2 Model 30 | 8086 | 8 MHz | 640k | 640k | 2-5.25" | DOS, Basic | $1299 |

**Continued from page 14.**

scripts. Our foreign study students register and pay tuition in Madison while they are abroad so they can apply for financial aid, if eligible, and there is no break in their academic connection to the UW. Their foreign academic work is on a "pass/fail" basis so the students' UW grade point average is not affected.

*Many of them return with an increased awareness and sensitivity not only to the people in other countries, but to their own circle of family and friends at home as well.*

Students have also told us that the addition of a study or work abroad period to their UW training has proven to be a real benefit when industrial representatives arrive on campus to begin job interviews. Those representatives realize that a good student who elects to study or work in a foreign country will often exhibit the same willingness to accept responsibilities and challenges in their future positions. Therefore, graduates with this foreign experience are very attractive to prospective employers.

*Many of them also return with a deeper understanding and appreciation of their own lifestyles.*

Students always manage to find some free time to travel and to join sports clubs and other student organizations. It is non-classroom activities of this nature which contribute significantly to the maturity and personal growth of the students. Most of them return with an increased awareness and sensitivity not only to the people in other countries, but to their own circle of family and friends at home as well. Many of them also return with a deeper understanding and appreciation of their own lifestyles.

If you have questions or would like more detailed information, please contact the International Engineering Programs Office. Phone: (608) 263-4811.□

# Monday Night at the Blues Jam!

**By Chaz Spengler**

The horns channel on the public address system was out but it just didn't matter. The blues flowed anyway. The base walked, the guitar wailed, the sax sung, the drums shuffled and the keys ran, rung and ripped. This is the dark, homey if not smoky Club de Wash. It's Monday night— a Monday night not to waste studying.

The Monday night blues jam has become a permanent fixture at the Club. While it has gone through three different incarnations, its quality has remained the same, excellent. It started out as a man and his keyboard and the hope that other musicians would show up to jam. Sometimes it worked, sometimes not. Then four years ago, the Reverend Dippermouth took over and created a house band to open and close the show. The present version of the blues jam, headed by East Side Johnny, is the best yet. Every time I see them they do something different with their opening set.

The blues jam isn't expensive. Just two dollars at the door buys you all the blues you can handle. Anyone participating in the jam, receives a free beer of their choice. The jam session is usually just a I IV V blues chord progression, but anything more complex the players agree on is fine. Bring your own band if you like. A word of caution is in order— it is a blues jam so play the blues. Crowds have been known to react unfavorably to bands not playing the blues.

*Monday night at the blues jam.*

It usually isn't hard to get a table if you get there before nine-thirty or a booth if you arrive before nine. The best seats are up front in the Monona room, and if you want to talk without shouting in someone's ear, go to the booths. Dancing is encouraged, as it gives the musicians something to watch. The booze is reasonably priced and to quote Mr. East Side, "Buy a pitcher because a pitcher's worth a thousand words."

If you think you're not into the blues or worried that you'll get dirty in those muddy waters, think again. Blues music surrounds you in its various forms and derivatives. Ever hear of rock and roll? Wonder where it came from? Give ya a hint, it starts with a 'B'. Dig out your old Zep, Cream or Stones albums and give them a close listening. Let's not forget Jimmi Hendrix, not ever. The blues are even receiving airplay on commercial stations thanks to people like the Vaughn brothers (Johnny of the Fabulous Thunderbirds and Stevie Ray), George Thoroughgood, and the Georgia Satellites. If you still aren't convinced that blues are for you, go see the Blues Brothers movie.

I guess it's time to introduce you to the band, the guys that make the blues jam go around. On the far left of the stage playing a guitar through a memory man effects pedal is John Mehne, but you can call him East Side Johnny. Mr. East Side was originally asked by the Rev. Dippermouth to be his lead guitarist and on the Rev's departure he took over the burden of leadership. East Side's solos are always good. His day job is that of editor and publisher of the Badger Entertainer—he's a man of many talents.

The man behind the drum kit, Pat Greenan, is never without a good fill. Shuffle or samba, he's got the beat well in hand and when he's not playing at the jam he can be seen with the band Tara Paraphernalia. Dave Remitz got tired of bass solos so he stands on his head and chugs a beer instead. This is no mean feat. Dave can also be seen with the Brad De Haven Band and occasionally with Clyde Stubblefield.

What can you say about Pat Dieter? He plays sax like Cannonball Aterly and occasionally does a little dance on stage with his sax. Absolutely stunning. He

can be seen with Honor Among Thieves. Lastly, we have the new guy on the jam, John Chimes. John plays like a sedated Jerry Lee Lewis— you know, he'd be banging on the keys with his right foot if his synthesizer weren't so delicate.

If you want to play at the jam, just go up to East Side if you play guitar, or see Dave for the base, Pat D. for horns, and Pat G. for drums. If you brought your whole band, tell East Side and he'll arrange something. Don't get depressed if you don't get on the first time, there's always next week and you at least get a free beer. The whole object of the jam is to have fun, so eat, drink, and be merry, for tomorrow you have an ECE quiz.

For those of you who have a problem with Monday nights, there is another blues jam on Tuesday nights. I really can't tell you much about it because I haven't been there in about six months, but the word is that it's OK. It's held at O'cayz Corral. Catch you on the flip side.□

*We be jammin'.*

## Answers

### To "People You Should Know."

1. Don Morton
2. Mary K. Rouse
3. James Clapp
4. J. Leon Shohet
5. W.A. Beckman
6. John G. Bollinger
7. Kenneth A. Shaw
8. Donna Shalala
9. Don Woolston
10. Marion Beachley
11. James J. McNeary
12. Phil Kessel

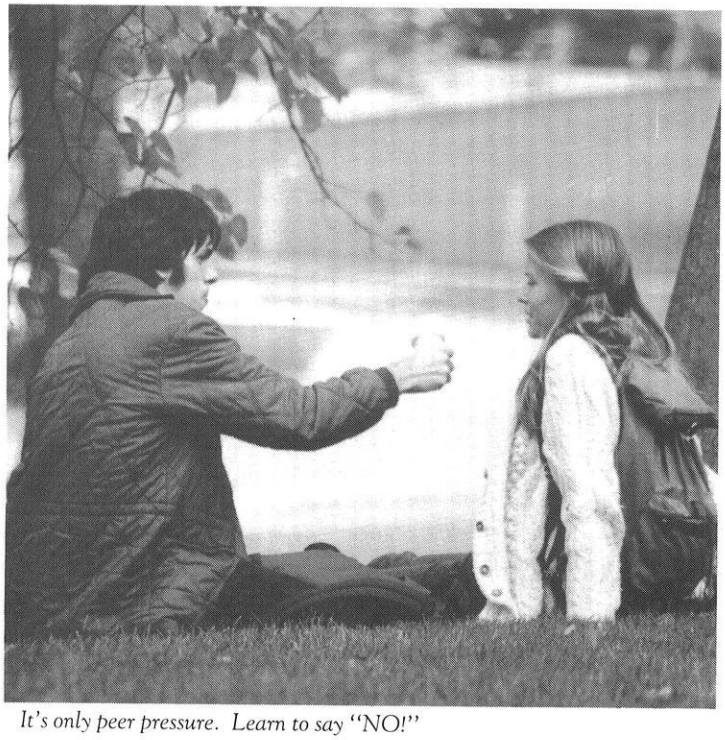
### To "Cultural Literacy Quiz."

1. Declaration of Independence
2. friend of the court
3. German good—bye
4. international monetary transactions
5. Soviet communist party
6. archaeological dating technique
7. characters in a play
8. said by Sherlock Holmes
9. E.T.'s full name
10. the unconscious
11. atoms of differing weight in an element
12. policy of delay
13. specialized vocabulary
14. approved by Jewish law
15. decaying disease
16. right—hand man
17. French for work
18. main character
19. neutrons and protons have them
20. stiff as a board (permanently)
21. Securities and Exchange Commission
22. shell beads for barter
23. famous Indian massacre
24. complementary opposites
25. low budget theatre.

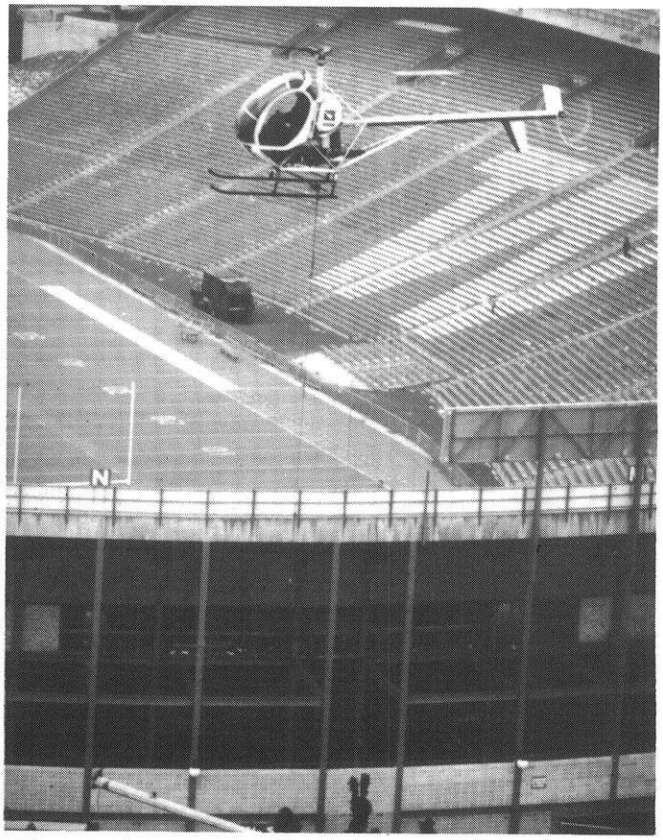
*The October 1987 Wisconsin Engineer staff sky-diving party.*

# Just One More

by Jerry Hill



*It's only peer pressure. Learn to say "NO!"*



*It's no wonder attendance is down at the football games this season. Would you want to be plucked out of the student section by a Per Mar stadium-sweeping helicopter?*

# *Darryl Greene knows that teamwork is the key to winning.*

Just a year out of school, Darryl Greene is responsible for supplies and services that support 14 major plants in GE's Lighting business.

What makes this young engineer so successful, so fast? His dynamic sense of teamwork is a big factor. He's got the confidence to interact with people at all levels. His personality inspires trust. He knows how to act like a leader, so his colleagues will act like a team.

Darryl knows it takes the best resources to back a winner. That's why he chose a job with GE.

GE provides unlimited scope for outstanding talents. The diversity—in businesses, resources, and locations—is second to none. Above all, there's a real willingness to give the ball to those who are willing to run with it.

If you want to be a leader, join the front-runner.

**The mark of a leader.**

*An equal opportunity employer.*