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March 1991

wisconsin engineer



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The cover is an example of the capabilities of ray tracing, which is featured in an article on page 13. Creators of the cover are Alex Dean (campus), Pat Lipo (robot), and Abe Megahed (composition and program).

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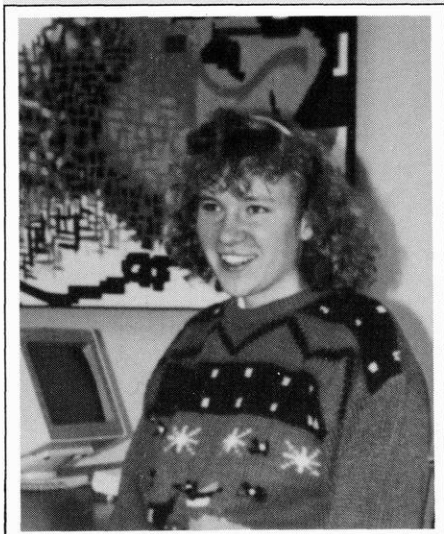
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EDITORIAL



Nancy Hromadka, Co-editor, *Wisconsin Engineer* magazine

In addition to its research, a university is also rated on its academic reputation and its instructional resources. The UW-Madison College of Engineering ranks 14th in overall effectiveness according to a study by U.S. News and World Report dated March 1990. A university, however, does not stay at the top of such lists by developing a good program and simply remaining the same. Similarly, a successful company does not develop a single product, market it and stop there. On the contrary, companies pour millions of dollars into research and development to continually improve their products. UW-Madison has a top-rated engineering curriculum, yet there is always room for improvement, and to remain at the top, we must continue to strive for those improvements.

At UW-Madison, freshmen and sophomores following the engineering curriculum are classified as pre-engineers and must fulfill certain requirements to be admitted to the department of their choice. When following the prescribed pre-engineering curriculum, often a student never comes close to the engineering campus until the second semester of his or her sophomore year. For an eager

high school student anticipating the challenges of a college engineering major, the thought of waiting two years to actually see an engineering class can be mildly disheartening.

Granted, the pre-engineering department does offer a survey class through the Engineering Professional Development Department which exposes freshmen pre-engineers to different kinds of engineering through speakers, but this course is only worth one credit and provides no hands-on experience.

An innovation in engineering teaching being tested at Drexel Institute of Technology in Pennsylvania introduces freshmen and sophomores to the engineering curriculum through an interdisciplinary course called Foundations of Engineering, a related hands-on laboratory course, and a design-oriented class known as the Fundamentals of Engineering. These courses integrate the concepts introduced in general freshman classes and attempt to provide beginning engineering students with a more realistic view of engineering in the working world.

Rhode Island University has also developed a freshman design class which ties together physics, chemistry, calculus and computer programming. Taking it one step further, Rhode Island professors have devised an engineering curriculum which requires a four-year design project that begins with fundamentals and increases in difficulty as the student progresses.

At the freshman and sophomore levels, there are many university students who are undecided about their majors. At UW-Madison, zoology majors can take introductory zoology courses as freshmen. The same is true for psychology and chemistry majors, along with several others. These introductory courses offer students a taste of their chosen field. The exposure helps to ensure them that they will enjoy their ma-

ior or provide them with an early indication that they may be dissatisfied with such a major. Engineering students, however, typically have to wait two years before being given this opportunity to 'test' out their major. By then, large amounts of both time and money have been sacrificed to simply change majors and start over. An introductory engineering course open to freshmen could possibly expedite such a decision process.

Some people may argue that engineering technology is too advanced for freshmen or sophomores to understand without the background obtained from two years of university level math, science and computer classes. But, perhaps we need to give both our professors and our students more credit. ESTEAM is UW-Madison's own proof that students at this level can comprehend engineering concepts.

A fairly new program initiated by the pre-engineering department to attract students to engineering at UW-Madison, ESTEAM provides high school seniors a brief one-day taste of engineering. Professors from various departments offer presentations relating to their research, covering such topics as microelectronics, plasmas and superconductors. If this type of presentation can be understood by high school seniors, surely college freshmen and sophomores could tackle a more curriculum-guided presentation.

Such a course would take a substantial amount of time to put together and would require cooperation from the individual engineering departments as well as various departments in the College of Letters and Science. But it seems that with the high quality of professors and resources available to the College of Engineering, such a course is possible. And, in an attempt to retain our status as a top engineering college, such a course may be essential. ■■

DEAN'S CORNER

Under a headline of "Undergraduates at Large Universities Found to Be Increasingly Dissatisfied," the *Chronicle of Higher Education* recently ran a story about students' lack of personal contact at big research universities. I am happy to report that the article mentions nothing about the UW-Madison. Iowa, Texas, and Minnesota weren't so lucky.

One form of personal contact, advising, has long been a concern in the College of Engineering. Over the years the College has devoted resources and time to the full spectrum of academic, personal and career advising. Acting on that concern, the College promoted two recent polls of students, parts of which were directed towards determining the advising needs of engineering students.

Approximately 800 pre-engineers responded to a pre-engineering questionnaire in early November, and about 300 upperclassmen participated in a survey conducted by Polygon in late November. In this column, I'll share some of the results and indicate some approaches that could be used to better achieve your academic goals through better advising.

In the pre-engineering questionnaire, 94% of the students felt that they should meet with an advisor each semester; 88% felt that the SOAR program adequately informed them about first semester decisions; 81% knew where to seek academic advice within the College, and 75% felt that they knew where to go to get personal and career advising.

In the Polygon survey, there was a great deal of variation in the way students viewed advising. Over 80% said that they had an advisor, but 42% said that the advice they received was not particularly good. A somewhat surprising result was that students, when seeking academic advice, valued student advice more than faculty advice.

A preliminary analysis of these and other results from the polls indicates that the College can take steps to improve its

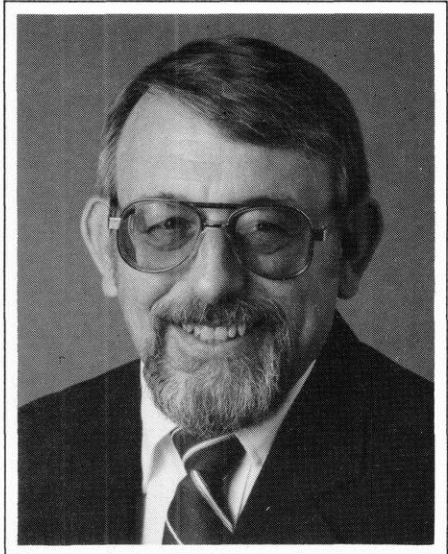
advising service. Clearly, it can communicate better with students (through the *Wisconsin Engineer*, for example). An obvious next step is to find out exactly what students need in the way of advice. Another approach might be to use students familiar with academic programs and have them work closely with advisors in the College.

Conducting these polls is only the latest effort that the College has made to improve advising. The College is unique for having diverted its own resources to hire its own counselor. Ms. Linda Schilling deals with the interrelated personal, career and academic needs of students. Each year, approximately 300 students visit her office.

Another way the College shows concern for advising is by placing academic holds on registration of pre-engineers who don't get advising. Although many students view the holds as an inconvenience, the College's view is that the goal is not to make every student happy, but to eliminate having seniors who have to spend an additional semester here making up unexpected deficiencies.

In addition to what the College is doing, I believe students themselves can improve the advising they receive. Here is some advice:

- 1) Take advantage of the knowledge of your assigned advisor. Every student has one, and it is part of his or her job to advise undergraduates. However, don't wait until the last minute. You will have better luck if you call ahead for an appointment.
- 2) Be informed. Study the information that your department makes available. Ask other students for courses and professors they recommend, but don't count on your friends to know about your degree requirements.



George Maxwell,
Associate Dean- Pre-Engineering

3) Be persistent. An engineering student I know interviewed different professors before she made a choice of majors. More students should be this assertive in getting information before they make decisions.

4) Leave options open. Specifically, over-enroll for classes at the beginning of each semester. If you have a course that might give you trouble, start out with enough credits so that dropping is an option.

5) Look down the road. Have a general plan for the next few years, particularly if you are in a small department. Courses may only be offered every other semester or every other year.

While you are working at implementing this advice, the College will continue to develop better means of advising students. Despite what you may have heard or read, faculty and advisors are concerned about students, but we all have to work around the demands on time that come with being at a university at the forefront of knowledge. If you have ideas for improving advising, I'd like to hear from you. ■■

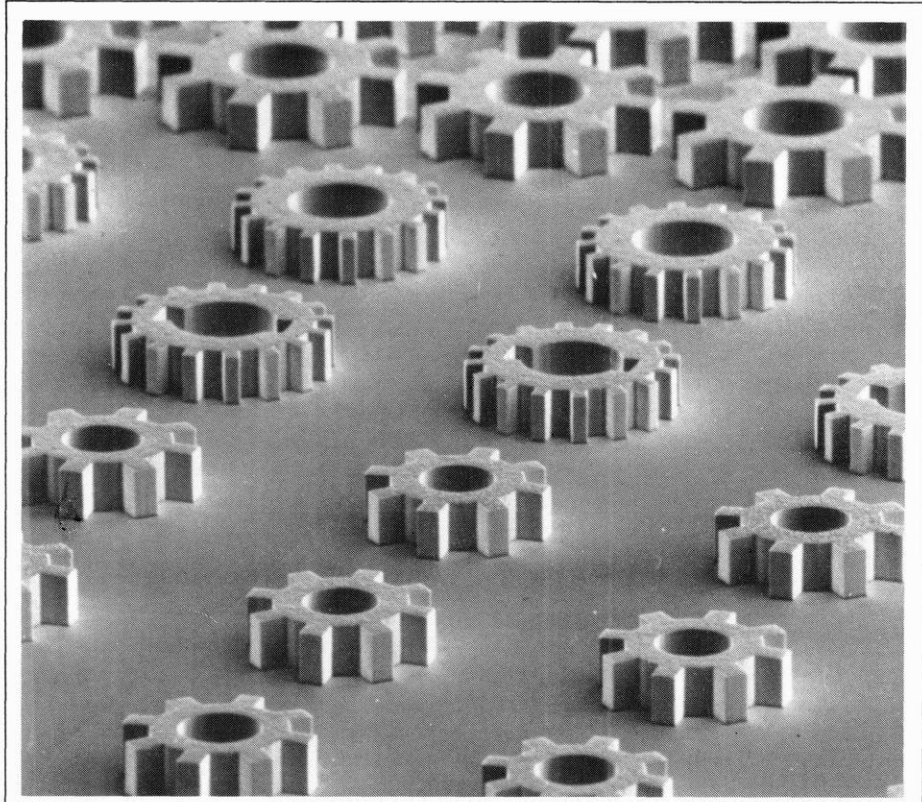
MACRO MINDS DEVELOP MICROMECHANICS

Imagine an airplane that can tell you if something is wrong with it and what needs to be serviced or replaced. For instance, consider a wing that knows how it is being deformed and strained, and can tell you what it has been through. Or a jet engine that can tell if any of its turbine blades need to be replaced. Such a plane might have averted the catastrophe of a United Airlines DC-10 jumbo-jet in 1989, which crashed in Iowa after an exploding engine cut off nearly all control of the airplane. A turbine blade in the jet engine was cracked, and under the stresses of normal operation with the blades spinning at very high speeds, the crack grew and eventually split the blade. The free piece of the blade tore through the engine casing and severed control lines to the rudder and elevators,

At the University of Wisconsin-Madison and at a private firm in Germany, methods of producing better and stronger microdevices are taking shape.

crippling the aircraft. Each jet engine contains many turbine blades, and even a tiny crack in one could lead to such a catastrophe.

Consider the advantages of putting miniature strain sensors on the turbine blades. During service checks on the ground, or perhaps even during flight, a tiny computer embedded in the blade could monitor all of the sensors and indicate which, if any, had experienced excessive strain. These blades could then



These tiny gears, less than a quarter of a millimeter across, were developed and made here at the University of Wisconsin-Madison.

be replaced, greatly reducing equipment failures.

The sensor system couples integrated circuits and the rising technology of miniaturized mechanical components, relying on both to yield a miniature system. An interdisciplinary link appears in more and more modern research.

Laboratories across the globe are investigating micromechanics, the field of miniature mechanical devices. At the University of Wisconsin-Madison and at a private firm in Germany, methods of producing better and stronger microdevices are taking shape. Rather than silicon, which is the conventional material, these researchers use nickel to make the devices.

In Madison, the team of researchers

consists of Professor Henry Guckel and Professor Denise Denton from the Electrical and Computer Engineering Department, Professor Edward Lovell from the Mechanical Engineering Department, Associate Dean and Professor Tom Chapman from the Chemical Engineering Department, and five graduate students. The team consults many other people, as the research encompasses several different fields, including integrated circuit fabrication techniques, material science, chemistry and engineering mechanics. Denton says, "The work we're doing involves all phases: how to make them, how to test them, and how to put them into applications. It's the whole range. It's very interdisciplinary, and you could say it's the wave of the future

to do interdisciplinary research. The walls are coming down between the disciplines."

Currently, microdevices are made from silicon, using some of the same fabrication techniques used with integrated circuits. To make a motor a tenth of a millimeter (or 100 microns) across, researchers at the Massachusetts Institute of Technology build up a sandwich of alternating

layers of polycrystalline silicon and phosphosilicate glass. Each of these layers has a different pattern, based on the final motor shape. After all of the layers are added, the phosphosilicate glass is etched away chemically, leaving only the silicon pieces. For example, to make the rotor, which is the part of the motor which turns, a layer of phosphosilicate glass is laid down. Then, silicon is added on top of it, in the desired rotor shape. During etching the glass is dissolved, leaving the rotor loose and free to revolve.

Many experimental and some commercially available devices have been fabricated. For example, miniscule silicon accelerometers, which measure acceleration, are already for sale. The accelerometer consists merely of a tiny weight at the end of a sensor that detects strain. Any acceleration moves the weight, deforming the sensor and generating a signal. These devices have many applications. For example, they can make an automobile safer in several ways. First, they can detect the sudden deceleration of a collision almost immediately, and trigger airbags to protect the occupants. Second, in conjunction with other circuits, accelerometers can sense when the car is starting to skid, and for a split-second allow the wheels to roll so traction is regained, helping the driver keep control



Professor Denice Denton of Electrical And Computer Engineering at the University of Wisconsin - Madison.

of the car. Finally, accelerometers can be used with an active suspension system, keeping the car level during turning and braking. This balancing helps keep the weight loads on the tires even, reducing the chance of skidding.

Some devices are made to move, such as motors and valves. For example, the motor from MIT spins at up to 2,500

"The work we're doing involves all phases: how to make them, how to test them, and how to put them into applications."

revolutions per minute. In the 1970s, researchers at Stanford University made miniature silicon valves for a gas chromatograph, a device that determines the composition of a gas by determining the weights of its constituent molecules. Work done by AT&T has demonstrated miniature turbines that can rotate at speeds of up to 600,000 rpm. A possible application for a device with a motor is a tiny free-floating device tipped with a drill, for working in blood vessels, cleaning off the walls and reducing the need for bypass surgery.

These devices use two different forces for creating motion. One is

electrostatic force, which is the same force which makes dust stick to TVs, or which holds a balloon to the ceiling after being rubbed. This force results from the repulsion of electric charges of the same type, or the attraction of electric charges of opposite types. Electrostatic force is relatively strong for micromachines because the force increases as the separation between the

charges decreases. To make a motor turn, one must charge the rotor (which revolves) and part of the stator (which does not move) with opposite charges, so they move toward each other.

Another force which is exploited to create motion is the piezoelectric force. The shrill alarm in a wristwatch comes from a piezoelectric crystal vibrating. When a voltage is applied to such a material, it bends (and conversely, when bent, it generates a voltage). Such a material can be applied to micromachines, enabling them to move very precisely. Researchers at Stanford University have made a device using piezoelectric elements to steer the tip of a scanning tunnelling microscope. Invented by IBM, this type of microscope can actually produce surface maps of materials which show the bumps of the individual atoms.

As inspiring and glamorous as this technology may seem, some substantial hurdles must be overcome. Denton says, "Powering them is a real problem. Telemetering information from them is not a solved problem, either." For example, devices relying on electrostatic force require 200 to 400 volts to move. This is almost 100 times higher than the levels normally used by the circuits that would control the devices. In addition, if the device is going to be able to wander on its own, for example in search of artery or

vein walls in a patient, it needs a power source. Miniaturized conventional batteries would not have nearly enough energy to power these devices for any length of time. There are certain methods possible for transmitting energy to the devices, but a very large amount of research needs to be done on that field alone.

Besides getting power in, one needs to get information into and out of the device. For mobile uses, radio transmission seems to be the only viable option, but antennas get less efficient as they shrink in size. A microdevice would need to use much more power to compensate, which intensifies the power source problem. Other techniques, such as a flashing light for signalling, could only work for applications where the device is always visible. This greatly reduces the possibilities for optical communication, as most uses, for example artery cleaning, would not qualify. Attaching wires to the device would weigh it down too much for free-moving applications. Transmission of information is necessary in many applications.

A more fundamental problem is that of force. As a device might need to move things, whether internal gears or a whole machine, it is essential that the motors be

strong enough. Denton says, "One of the rules of thumb that I've heard is that until they can move a gram, they're still experimental." This feat is beyond today's devices. Once the force problem is resolved, one must determine how to connect the device to the physical world. Research needs to be done on the mechanical linkages and their properties on the micro scale.

The material polycrystalline silicon itself, which most microdevices are made of, presents problems. According to Denton, "You can't grow polysilicon films more than a few microns thick; they just tear themselves apart. Polysilicon in general doesn't have the best mechanical properties. It tends to shed, so you'll have little pieces of it coming off. If you're trying to build a bearing surface and you get chunks in there, it will tear itself apart." In addition, two metals rubbing against each other will eventually freeze up and stick. This binding happens sooner with silicon than with some other materials. Researchers at AT&T found the lifetime of a polysilicon turbine operating at 300,000 rpm to be just three minutes. Silicon has the strength problem and the friction problem, together with the limitation of a device's thickness to only a few microns. Research is being

done here at the UW-Madison to develop the use of more suitable materials for the tiny components.

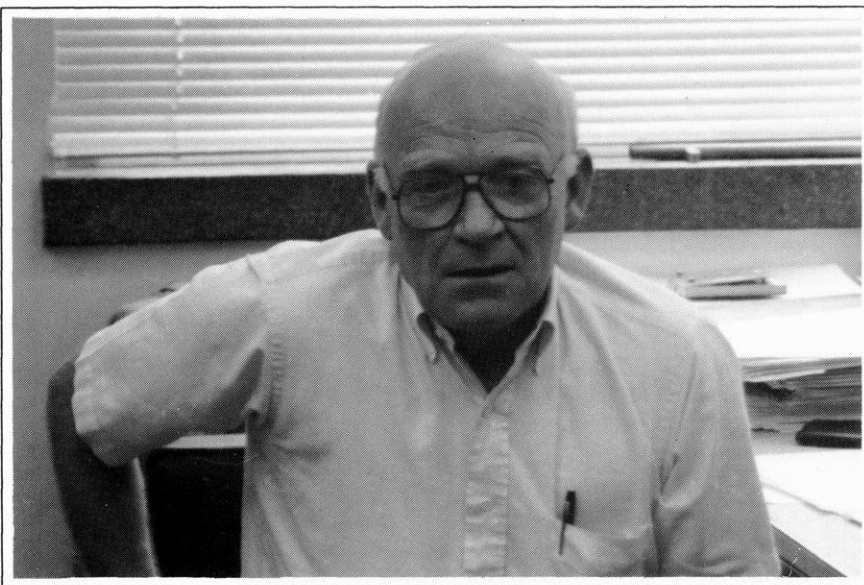
By using a somewhat different process, researchers here are able to fabricate items from nickel up to 100 microns thick. Although 100 microns (a tenth of a millimeter) does not seem like much, it makes a big difference, as it is many times thicker than the devices made from silicon, and therefore much stronger. Nickel is better than silicon because it is stronger and resists wearing better.

The first step in the fabrication process consists of depositing a thin layer of

"Considering the societal changes resulting from the strides which integrated circuit technology has made in its short 30 year lifespan, these microdevices might similarly redefine our world."

metal on a very smooth surface, such as the kind of silicon wafer used for manufacturing integrated circuits. This layer is then covered by about 100 microns of an X-ray light sensitive polymer called photoresist. The polymer is prepared by baking it at over 100 degrees Celsius (212 degrees Fahrenheit) for 22 hours. The material is then taken to the University's Center for X-Ray Lithography, where parts of it are exposed to X-ray energy. X-ray's are needed to penetrate the thick photoresist, as they are more intense than visible light, which is used for manufacturing integrated circuits. After a 90 minute exposure, the wafer is placed in a developer bath, which eats away the photoresist which was exposed to the X-ray energy. What remains is a template, with metal uncovered in certain areas.

The wafer is now placed in an electroplating bath, in which nickel is electroplated to the exposed parts of the metal base. After the electroplating, the remainder of the photoresist is exposed and developed, leaving the tiny device on the base. For removable devices, an extra layer of polymer is put on the wafer before the thin layer of metal. After electroplating, all of the polymer is etched away, including that which secures the



Professor Henry Guckel of Electrical And Computer Engineering at the University of Wisconsin - Madison.

part to the wafer.

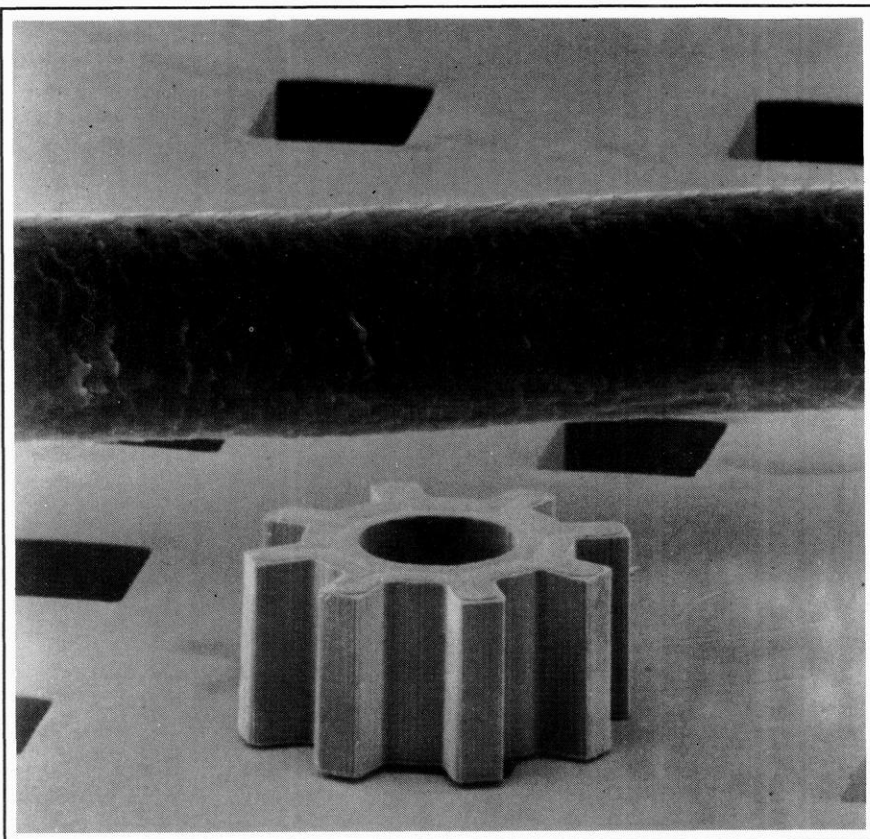
The research being done here at the UW-Madison and at a private company in Germany does have limitations which are receiving attention. For example, to expose the thick photoresist, a high energy X-ray source is used; here, the Synchrotron at the UW's Center for X-Ray Lithography supplies the energy. There are very few facilities available which provide enough energy, and they are expensive. As a result, companies in Japan are trying to make a desktop X-ray generator for this process. Others are trying to use ultraviolet energy to expose the photoresist. UV has more energy than visible light, but not as much as X-rays. Using UV energy would make the process more readily available, as many integrated circuit manufacturers use UV in circuit fabrication.

This exciting field has tremendous opportunities, and significant work remains to be done. Considering the societal changes resulting from the strides which integrated circuit technology has made in its short 30 year lifespan, these microdevices might similarly redefine our world. Many problems in manufacturing as well as design are still hidden, and they will need to be solved. According to Denton, "It's still in its infancy. It's very hard to predict these things. It'll depend a lot on solving these problems— power distribution, high power levels, information control, telemetry, and force. There are a number of obstacles that need to be overcome, but it's possible that micro-mechanical devices could really take off." ■■

Photos courtesy of UW News & Information and Chris Bergquist.

AUTHOR

Alex Dean is a senior in electrical engineering and Spanish. He enjoys spending his free time sailing the lakes of Madison and beyond.



To get an idea of a gear's size, here one is shown beneath a strand of human hair.

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TRACE CENTER TARGETS TACTILE TECHNOLOGY

HELPING THE BLIND TO 'SEE' WITH COMPUTERS

Imagine yourself seated in front of a Macintosh computer. You are typing a lab report. You've been sitting there for over an hour. It is almost complete. You last saved your file about 15 minutes ago. Suddenly, your screen goes blank. The computer still works, but you can't see where the cursor is. You want to save the rest of your report before you try to restart the machine, but you are not sure what to do. So, you move the mouse around and hope you can find the save option on the menu bar.

Trying to locate items on a screen without actually being able to see them is an obstacle that blind computer users en-

Although their sense of touch is acute and has been developed to take over part of the job of their eyes, it is still extremely difficult for them [the blind] to distinguish items on a computer screen without the use of sight.

counter everyday. Although their sense of touch is acute and has been developed to take over part of the job of their eyes, it is still extremely difficult to distinguish items on a computer screen without the use of sight.

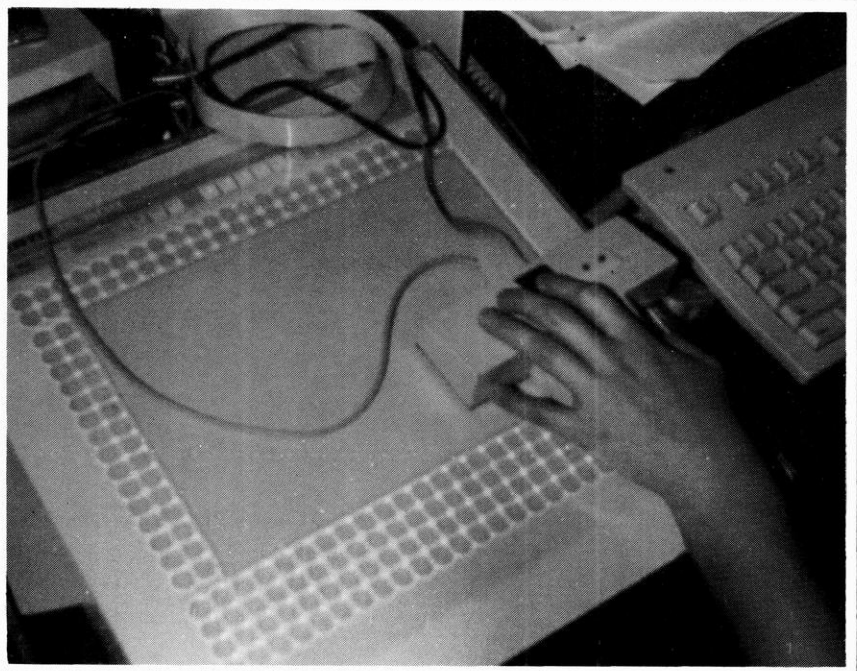
Here is where the Trace Center steps in. The Trace Research and Development Center, located in the Waisman Center at the University of Wisconsin-Madison, works to improve the quality and effectiveness of the communication and computer access systems available to

disabled individuals.

Currently, a team of researchers is investigating methods of improving access to graphics-based computers for blind or visually impaired users. The project, entitled "Systems 3", looks at three different strategies of computer screen access. Each method combines a voice synthesizer with a corresponding counterpart. System 1 consists of a software program designed to provide full access to the computer screen through use of the keyboard. For

example, pressing a sequence of keys moves the cursor to a particular spot on the screen, like the menu bar, and the voice synthesizer announces this position by saying, "menu."

System 2 relies on the use of a touch tablet similar to a standard digitizing tablet found in most computer-aided drafting labs. A plastic sheet with small indentations is placed over the tablet, and a mouse-like puck is used to navigate the board. The tablet corresponds to the computer screen



The touch tablet shown above features a plastic surface with small indentations which represent the various icons on the computer screen. A voice synthesizer provides feedback.

with each indentation representing a particular reference point such as the menu bar, the hard drive icon or the trash can. The menu indentations are found at the top of the tablet just as they are found at the top of the computer screen. Again,

To accommodate hearing impaired users, the volume level can be adjusted. When set to zero, the menu bar flashes on the screen in place of the familiar beep indicating an error.

the voice synthesizer provides verbal information for the current position on the screen.

The third system takes System 2 as a starting point and builds up from there. System 3 allows the user to actually feel the items displayed on the screen through the use of a hand-held device containing a vibrating tactile array.

The T-shaped device resembles a hand-held scanner and has a one-inch square section of 100 tiny metal pins which can vibrate individually to model the shape of the screen image under the cursor.

The vibrating array in the T-shaped puck was adapted from an older device known as the Optacon, originally developed to enable blind people to read printed text. The Optacon consists of a hand-held camera and a small box containing the tactile array. As the tiny camera lens is passed over printed material, the Optacon generates the video image with the array of vibrating pins.

David Kunz, a mechanical engineering Ph.D. candidate at the UW and a member of the Systems 3 research project responsible for hardware development, basically removed the tactile array from the Optacon and built it into the T-shaped puck. The Optacon construction is based on a bimorph technology. A bimorph is a layered device that actually moves a small amount when a voltage is applied to it.

Through efforts of the Trace Center and similar organizations, computer manufacturers have incorporated design suggestions into standard features of their machines aimed at obliging impaired individuals. Examples of such design considerations include the location of power switches, the adaptable positioning of computer monitors and the brightness of screen colors.

Apple Computer has been very responsive to design suggestions in these areas. They have integrated several features right into their operating systems.

One Finger is a setup that permits key combinations such as option-eight, command-period, or control-c to be invoked as a series of key sequences rather than a combination. This feature is available in the Easy Access file of the operating system.

In the control panel, the key repeat rate can be adjusted so that a slower typist, perhaps one with motor difficulties, can type one letter at a time instead of ten with the press of a single key. The auto repeat feature can also be turned off completely.

To accommodate hearing impaired users, the volume level can be adjusted. When set to zero, the menu bar flashes on the screen in place of the familiar beep indicating an error.

According to Peter Borden of the Trace Center, "These features have been built right into the computer by Apple, and they are not in the way of able-bodied people using the computer, yet they are available for disabled people at no extra expense."

The Optacon requires five layers of bimorph and circuitry to drive each pin in the array. A circuit board converts information from the camera to move the pins. Kunz's design goals included making the puck small, lightweight and convenient. He wanted to make the puck easy to move across the tablet while allowing one finger to remain on the array at the top of the device. The prototype is complete, but Kunz says some changes are still necessary; he notes, "The puck is still too heavy."

Explaining the motivation behind this research, Communications Director at the Trace Center, Peter Borden states, "We're trying to find strategies for blind people to deal with new designs of computers and computer software."

"Back in the early '80s before Macintoshes came out, there were ways that blind people could access the screens of computers that were developed that were reliable but depended on the technology that existed at that time."

All of the computers popular before Macintoshes used character-based screens. The contents of the screen were stored in memory as ASCII characters. To make this information accessible to

blind users, memory merely needed to be read and then sent as a string of characters to a voice synthesizer. Cursor location on the screen was found by synthesized announcements of line and column numbers. The screen was always a perfect grid and each character corresponded to a specific cell.

According to Borden, "They dumped all that when they built the Mac."

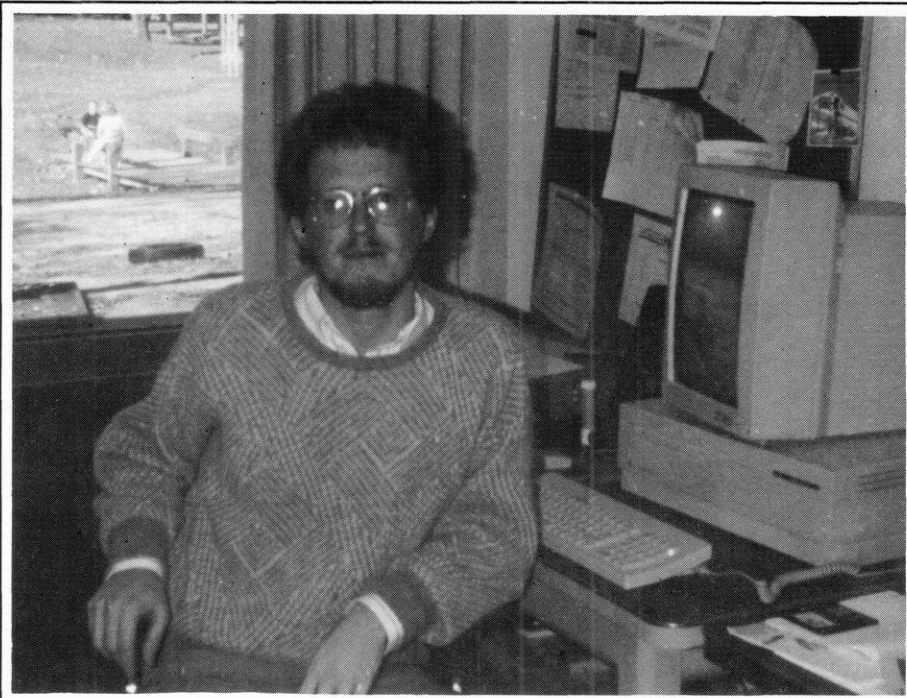
"The ultimate goal of it is to determine whether a system like this could be used effectively by blind people and then figure out whether it could be made commercially available."

You have these windows that you can stretch and shrink and menus that pull down. You have fonts that are different sizes and widths so the characters don't occupy the same horizontal space on the screen anymore. There are icons that are just pictures or don't have ASCII equivalents.

Gregg Vanderheiden, an associate professor at the University of Wisconsin-Madison, began the Trace Center as a student project in 1971. The project started with a communication system for a young boy with severe athetoid cerebral palsy. The center now houses a variety of projects, from auditory computers to resource books for the disabled. Vanderheiden's help with the Trace Center is invaluable for both the disabled and able bodies. He cites the slanted sidewalk curbs for wheel chairs as an example. These ramps provide easy access for both bicycles and pedestrians. Dealing with the highly technological part of the market for the disabled, the center needs large amounts of funding. Vanderheiden has obtained funding through a variety of organizations outside of the University.

Starting with small award money and public school funding, the Trace Center has grown with funding from 12 different organizations. Having been awarded a grant from the NSF, National Science Foundation, in 1973, Vanderheiden stopped at the NSF on his way to the east coast to thank the foundation. The Director for Education at the NSF commented on the work of the Trace Center and said, "This work should not end." The funding has now grown to support the staff of over 30 people. Although the Trace Center is no longer a student run organization, it is still directed by Vanderheiden and employs students from many classifications.

The leadership of Vanderheiden has developed the Trace Center into a leading organization in the field of disabled technology. The Trace Center is reaching people all over the nation with the vast new technology in this area. With the work done by the Trace Center, the world is made easier for all people.



Peter Borden, Communications Director at the Trace Center, is a former Wisconsin Engineer staff member.

"There are a lot more different kinds of information on the screen, so the spatial orientation of the screen is much more important." Computers with these types of displays use graphics-based screens. "It makes it much more difficult to develop and adapt each device to allow a blind person to read the screen," says Borden.

The tactile array is useful for information that the voice program has no way of expressing as speech. Graphics such as lines, boxes, pie graphs and bar charts are more easily understood visually or tactilely than verbally.

"The ultimate goal of it is to determine whether a system like this could be used effectively by blind people and then figure out whether it could be made commercially available. Most of the past year has been spent on software design, perfecting the way the tablet communicates with the screen through software," explains Borden.

Research began with the Macintosh computer because it is the most mature of the graphics-based systems, says Borden. Stressing the timeliness of this research, he insists, "Now is the time to deal with it, not in ten years when everything is graphics based."

The next phase of the project will

look at the ways blind people most effectively interpret information. "In other words, when you're designing the system, what sort of controls do you want to give to a blind person so that he can most quickly and easily get a handle on what he's 'looking at' on the screen? We need to look at how the blind are accustomed to receiving information," says Borden.

The four project areas that the Trace Center emphasizes are hardware and software development, factors in human perception, training methods and devices, and commercializing procedures. There are still several factors which need to be considered, modified, or further developed before such a system can be made commercially available. A major obstacle at the present time is the high cost of the hardware and software of the system itself. Borden notes that research will continue for at least another year or two before the system can be presented to the public. ■

AUTHOR

Nancy Hromadka, one of our fearless co-editors, enjoys volleyball as well as many other sports.

EXPO '91

VISIONS OF SUCCESS

SPECIAL EXPO STUDENT EXHIBIT SECTION

Expo '91, a three day event to be held April 19-21, 1991, gives the public an opportunity to view recent technological developments in the UW-Madison College of Engineering as well as in private and governmental sectors. Expo is a non-profit, *entirely* student-run and organized event which has been held approximately every two years since 1940.

Expo '91 serves several purposes: to educate and inform the general public about the engineering profession; to expose high school students to aspects of different engineering fields; and to enable university students to demonstrate their skills in technical projects.

Expo '91 will feature student, industrial, and governmental exhibits throughout the engineering campus. This year's special exhibit theme is *Sports and Engineering*. Organizers are anticipating the largest turn-out of both exhibitors and spectators in the history of Expo, exceeding Expo '89's number of nearly 20,000 visitors.

FUNCYCLE

If you have ever used an exercise bicycle on which you spent countless minutes staring at the wall in front of you and thinking that there must be a more enjoyable way to shed those pounds, then you should take a look at the Expo project that an interdisciplinary group of engineering students are working on.

The students plan to connect an exercise bicycle to a flight simulator program to make exercise more fun, says Jeff Aberle, one of the students involved in the project. A person pedals the cycle and uses a joystick to control the flight simulator program which is shown on a screen.

As one pedals faster, the speed of the plane increases. As the plane ascends,

pedaling becomes harder. One can turn the plane by moving the joystick to the right or left. For added effect, the seat of the exercise cycle also moves as one turns. The cycle will also have traditional features such as a Calorie counter and an odometer.

Two computers will be used, according to Aberle. One will run the program and the other will compile and control sensory information.

The project is sponsored by Marquip Inc., a local engineering firm, and involves electrical, mechanical, chemical and industrial engineering students from Tau Beta Pi and Kappa Eta Kappa.

by Nazima Jaffer

MOONRACER

Have you ever dreamed of going to the moon? Well, maybe EXPO '91 won't bring your dreams to life, but perhaps they can offer the next best thing.

In order to increase public awareness about on-going space research at the UW, AIAA (American Institute of Aeronautics and Astronautics), a student group composed mostly of engineering mechanics majors, is constructing an artificial lunar landscape as part of their EXPO '91 exhibit.

The project relates to NASA's proposed mission to mine helium-3 from the surface of the moon. Helium-3, also known as 'Astrofuel', is a special isotope of helium not commonly found on earth. It is rich on the surface of the moon because it is a by-product of the sun's fusion and is carried through outer space by the solar winds. Our atmosphere protects us from the solar winds, but our unprotected moon is continuously bombarded by helium-3, which becomes

imbedded in the lunar soil. NASA finds this isotope of particular interest because of its promise as a highly-efficient, minimally-radioactive fusion fuel in future commercial fusion reactors and propulsion systems for space vehicles. The bulk of the research, planning, and development for this proposed mission is being done by UW faculty members and students in conjunction with WCSAR (Wisconsin Center for Space Automation and Robotics).

The artificial lunar landscape will serve as the arena for a 'Lunar 500' of sorts, as EXPO '91 visitors will be allowed to 'race' remote-control vehicles around strategic checkpoints on the course. The vehicles are to demonstrate the remote commands that NASA technicians will have to transmit from Earth to the lunar helium-3 mining vehicle during the mining operations. By means of a computer program, the motion-control commands will be time-

delayed. This feature will simulate the three-second delay experienced by NASA technicians due to the time it takes for radio wave commands to be sent and visual image transmissions to be relayed from the moon.

AIAA expects the time-delayed controls to make the 'race' a virtual 'demolition derby', but they are taking precautions to make sure the vehicles make it through the race weekend intact. A video camera will also be used to monitor the movement of the 'lunar vehicles' around the course.

In addition to their demonstration project, AIAA also plans to have a videotape presentation of NASA's lunar mining plans, free literature to explain vibrations testing, AIAA t-shirts (\$10) and sweatshirts (\$18), and 'exclusive' UW College of Engineering car-window stickers at sub-Bookstore prices.

by Mike Waters

AUDIO EXPLORATORIUM

Once again, the Society of Women Engineers promises an exciting and beneficial Expo exhibit. SWE's Audio Exploratorium will provide a work-out for the eardrums of both the young and the old. The Audio Exploratorium is modeled after a very popular interactive learning exhibit in San Francisco. Designed by SWE member Todd Brennan and crew, the SWE exhibit will feature five or six stations of related audio projects.

The first four of these stations will be centered around black boxes. The first black box will demonstrate a clipping circuit in which sound waves are cut off, or "clipped." The box will take in normal sound and distort it. This station will be especially exciting for fans of rock and roll, as they will recognize the technique of their favorite electric guitarists.

The second black box will unfold the hidden mysteries of the portable ampli-

fier. All Expo-goers passing through this station will receive detailed instructions on how to build their very own portable amplifier at home.

The third black box will demonstrate noise levels, known as the "signal to noise ratio," in different audio devices. Visitors will be able to explore the difference in sound quality of compact discs, cassettes, telephones, etc.

Adjacent to the signal to noise box will be a crosstalk box. Wires from the crosstalk

box will be near the signal to noise box, picking up sound. This station will demonstrate signal leakage.

Another station of the SWE Audio Exploratorium will feature a digital sound processing center. Several black boxes will be programmed so visitors can see how different sound technologies compare. These comparisons will make it possible for one to see the difference

between analog clipping and digital clipping, and between analog and digital distortion.

One of the highlights of the SWE exhibit will be in the form of a hearing loss simulator. The simulator will remove high frequencies from the sound that the audio-explorer will hear, creating the illusion of hearing loss. The purpose of this station is to increase awareness of hearing loss. Plenty of hearing loss information will be on hand.

The most exciting feature of this Expo exhibit is that it is portable. After Expo '91, SWE will take its show on the road, integrating the Audio Exploratorium into the high school and junior high outreach programs. Getting young people excited about science now is a good way to ensure an awesome Expo '95 project!

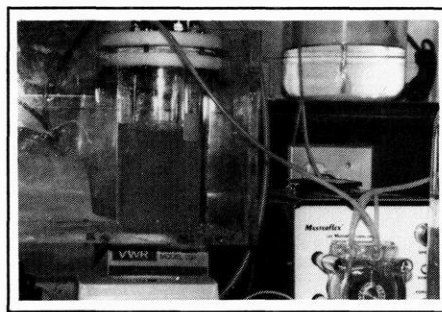
by Amy Damrow

BACTERIA LUMINESCENCE

In the fifteenth century, sailors noticed that sometimes the sea would glow at night. The same phenomenon that baffled these seamen is the subject of Hari Nair's EXPO project.

The mysterious glow is caused by a mixed strain of photobacterium that live on the skin of fish. In nature, the fish and the bacteria have an important relationship. The bacteria get their food from the fish, and the fish get valuable light from the bacteria. This light allows the fish to find food and avoid predators.

At EXPO, however, the bacteria will not be living on fish. Instead, they will live in a fermenter. According to Nair, the most difficult part of raising the bacteria is trying to keep them glowing. When bacteria build up excess energy, they may expend it in three ways. They



Bacteria contained in a fermenter, as shown above, are the subject of Hari Nair's Expo project.

can grow, reproduce or glow. Since growing and reproducing take precedence over glowing, it is very difficult to add just enough food to achieve the desired glowing effect.

Bioluminescence has been researched and used in industry since the late 1960s. For example, photobacteria are used in assay tests, which measure the alpha and gamma rays in toxic wastes by measuring the luminescence of bacteria exposed to those rays.

Nair, a third-year chemistry major, is working on the project under Dr. Douglas Cameron, Assistant Professor of Chemical Engineering. Also involved in the project is Carolyn Dunkel, a student in the School of Education, who is producing the visual presentation of the bacteria at EXPO. Pro-Mega and Madison Biotechnical Resources have contributed money to the project.

by Annelies Howell
photo by Jason Shirk

RAY TRACING

Novels, movies, television shows, theater, radio drama, computer games — all of these are attempts to create or reproduce part of reality in some form. To varying degrees, they require us to suspend some of our disbelief in order to create the illusion of another world. Whether it is imagining the stormy ocean scenes described by Jack London in *The Sea-Wolf* or rolling in a movie theater seat as the submarine *Red October* lurches sideways on the screen, these media do not provide a complete set of sensory inputs. Without information to fool all of the senses, the drama is not always completely engrossing. For example, with a book, you are looking at just words on a page, and they have to be translated mentally (albeit subconsciously, usually). In a movie, you get only limited sight and sound. If you look down, you see the person in front of you. The theater does not move with the action on the screen.

Perhaps just as significant, none of these media are interactive, except for computer games. You have no control over the protagonist as she wanders into the lair of a chain-saw wielding psychopath. Computer games do a great deal to put you in the driver's seat, but you still have to limit your perception to 100 square inches of video screen, or CRT, and ignore everything around it, like the power switch, the computer below and the wall behind it. And, the contents of those 100 square inches are often anything but realistic. As the CRT is merely a surface with no depth, the features seem toy-like, flat, and simply unrealistic.

Now, thanks to the continuous advances in electronic technology, it is possible to build a system which fools your eyes, ears, and, to some extent, sense of motion. It is a "virtual reality" system, consisting of a computer, a special helmet and other equipment. The computer's memory contains a list of what is in the virtual world, where it is, and what it looks like. In the helmet, two

tiny CRTs in front of your eyes provide visual information. Each eye sees only the image of one CRT, which allows a computer to generate a separate image for each eye. By displaying slightly different images, the brain can be fooled into thinking it sees a three-dimensional image, with depth and solidity. By using position sensors to determine the helmet's position and direction, the computer calculates where, in the virtual reality, you are located, and where you are looking. It then proceeds to generate an image corresponding to what would be seen if the virtual reality existed.

In order to generate completely realistic images, the computer needs to simulate the light's behavior in the scene. A technique for generating realistic images by calculating and modeling the

***ART is currently available
at UW's Undergraduate Proj-
ects Lab in the Computer
Science building.***

behavior of light rays is called "ray-tracing." The computer simulates sending out rays of light from the observer and determines what they run into, taking into account such physical phenomena as reflection, refraction and diffraction. The resulting image impressively duplicates the lighting, shading, reflecting and other properties of the real world.

The drawback to ray-tracing is the tremendous amount of computation which must be done to generate a scene; this requirement has limited its use to a few applications. The 30 seconds of computer animation used in television advertisements today is the result of many hours or days of computation. With this restriction, ray-tracing cannot be used for virtual reality, as most computers are far too slow. Those computers which are fast enough are

usually far too expensive to be used for such an application. A few companies have introduced virtual reality systems with limited performance and extremely high prices.

In order to speed the ray-tracing calculations at a low cost, several students at the University of Wisconsin-Madison have chosen to design, build and program a small computer specifically for such processing. Called ARM, a ray-tracing machine, it is a computer designed to reduce the cost of ray-traced graphics. Contained within ARM is an extremely high performance microprocessor, which does the computations and sends the image information to a low cost Amiga home computer. By limiting the capabilities of ARM to only those needed for raytracing, much money can be saved. For example, ARM does not have a costly disk drive or monitor. It runs a program called ART (Abe's Ray-Tracer, after the author, Abe Megahed), which does the necessary calculations. ART is currently available in the Undergraduate Projects Laboratory in the Computer Science and Statistics building; it runs on Amiga, Hewlett-Packard Bobcat, and DecStation 5000 computers. With luck, this graphics sub-system can be used as a key piece of a virtual reality system.

ARM and its support computer, needed to specify and display the images, will be displayed at Expo '91. Price and time considerations rule out the demonstration of a virtual reality system, much to the regret of all of the team members. Still color images will be computed and displayed. The members of the team are Abe Megahed, who wrote the ray tracer program, Eric Bazan, who translated it to run on other computers, Alexander Dean, who designed and built the ARM computer, and Alain Kagi, who modified a program to aid in the development of other programs.

by Alexander Dean

PLASMA DEPOSITION UNIT

Olympic speed skaters may some day benefit from the findings of the American Society for Metals' 1991 EXPO project. Conforming to the 'Sports and Engineering' theme of EXPO '91, this student group project involves the development of a high voltage plasma deposition unit which can be used to change the surface properties of ice skate blades, making them more wear-resistant and decreasing the coefficient of friction between the blades and the ice.

"Ice skate blades actually go dull during a race," explains Joe Zanter, a senior in material science and engineering. He notes that the main purpose of the EXPO project is to provide the blades with better wear resistance for longer races. His group hopes to achieve this improvement by creating a diamond-like carbon coating on the blades of the skates.

The plasma deposition unit which produces this coating consists of a vacuum pump, a capacitor, a bell jar and a voltage source. The base of the unit is

approximately 16 inches across and holds two metal plates connected by wires. The ice skate blade rests on the lower of the two plates. When a voltage is applied between the plates, an electric field is set up and the plates behave as a capacitor. The mouth of a large glass jar fits over a circular section of the base, sealing off the internal components of the unit from outside influences. Tubing through the base provides the only link to the inner jar, connecting the vacuum pump and a source gas to the controlled environment.

Once the jar is evacuated, a carbon-based gas mixture, such as methane or acetylene, is piped into the unit. This gas provides the source of the plasma which is created at a potential of about 700 volts and a pressure of approximately one torr.

As the particles of this gas enter the electric field between the plates, their atoms become ionized and a plasma is created. The positively charged ions accelerate toward the negatively charged

plate which holds the skate blade. When the charged particles hit the blade, a chemical reaction occurs, creating a thin film of diamond-like carbon on the blade's surface.

The process implemented here parallels a similar procedure known as ion nitriding which uses a nitrogen-based plasma and deposits particles on a steel or titanium alloy. When the nitrogen ions hit the surface of a specimen, a chemical reaction occurs and a nitride layer is formed.

Referring to the coating process, Zanter says, "We're incorporating materials and sports. This project is one of three parts. It's basically a prototype model of what's going on in another lab on a much larger scale." The other two parts of ASM's EXPO project include a second plasma deposition unit, powered by microwaves instead of high voltages, and a bicycle frame display illustrating material joining and welding technologies.

by Nancy Hromadka

AQUACULTURE

How does engineering apply to raising fish? The student branch of the American Society of Agricultural Engineers is working on a project to demonstrate the link between aquaculture and engineering.

Keeping water free of chemicals and providing an ample supply of oxygen are two primary problems the group is trying to solve.

The fish will be swimming in raceways, long rectangular ponds designed to promote fish growth. An oxygen meter will read the concentration

levels in various areas of the water. Research predicts that the fish will be attracted to the more heavily oxygenated areas.

A fish feeder is another part of the project. Feed for the fish will be controlled automatically by a string. When the fish pull down on the string, a measured amount of feed will drop into the water.

The project is modeled after the natural springs in Idaho, where the water temperature is 50 degrees Fahrenheit. In the springs, there is constant

water movement and an abundance of oxygen.

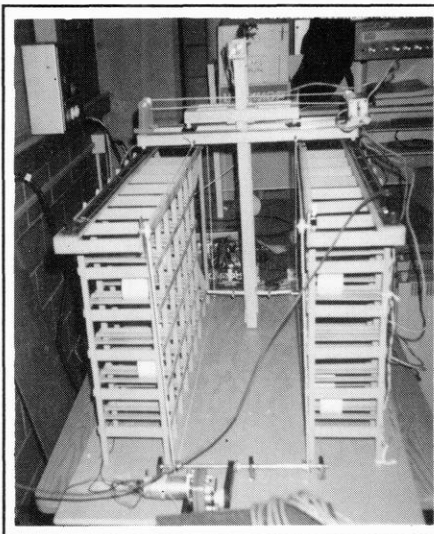
The Department of Agriculture at UW-Madison, the Department of Natural Resources, and Rushing Waters, a fish farm with artesian springs, have helped contribute to the group's EXPO project information.

by Amy Erickson

THE AUTOMATED WAREHOUSE

Imagine the ease of life if you had a robot to store and retrieve all of your personal items in your home or apartment. The technology to perform this feat is being implemented in many of today's industrial settings. One EXPO '91 project group wants to improve this concept by utilizing a "smart storage" algorithm.

The project, headed by students Steve Nelson, Greg Hawley and Ray Juskot, will implement mechanical storage and retrieval of warehouse materials using fully-automated computer controls. Nelson notes, "By using this system, there would be no one (needed) in the warehouse whatsoever". He adds, "It's totally computer-controlled, unlike current systems which use PLC's (programmable logic controllers) and relays." The idea is based on Nelson's co-op experience at Inland Steel where he witnessed the operation of Automated Guided Vehicles (AGVs) in the warehouse.



The above picture shows an example of an automated storage system.

The complete project system will use one AGV to transport material from the assembly line to the warehouse, a

crane to store and retrieve the material, and a second AGV to transport the material to the shipping area. The software is completely written using "C." The software directly controls both the DC motor, which moves the crane the length of the warehouse bay, and the two stepper motors, which adjust the crane arm height and depth into the storage bin area.

The system uses the MicroVAX 3300 with a 10-bit microprocessor with parallel input and output ports. A user-friendly windowing utility is provided by the MOTIF operating system. The EXPO project can also implement the "smart storage" algorithm, whereby the computer will take the material details from the user and evenly position the material for structural purposes. Total project expenses to date have been funded by EXPO '91.

*by Paul Derbique
photo courtesy of Steve Nelson*

LASER BILLIARDS

The EXPO '91 project under development by the student chapter of the Institute of Electrical and Electronics Engineers (IEEE) promises to make a pool shark out of almost anyone. The project uses a laser and a mini-computer to detect the position of billiard balls and to direct a pool player to sink a target ball into a given pocket.

The laser scans the billiard table to map the position of two balls. A minimum of two mirrors is required to pinpoint a ball. The laser is secured to a stationary mount and directed to the first

mirror. This mirror revolves and a detector reads light reflected back by a ball. When detected, the angular position is fed to a mini-computer. Next, the first mirror reflects the light to a second mirror. From there, a second angular position is determined and fed to the computer. With these two angles and the distance between the mirrors, the position of a given ball is determined by angle-side-angle triangulation.

Once the laser's reflection off of the balls is detected, the information is entered into a computer. Based upon the

location of the balls, the computer calculates how one ball should be struck to knock the other into a given pocket. Finally, the person behind the cue stick is directed to hit the cue ball in the correct direction.

by Douglas Maly

TREK

THE NEXT GENERATION OF BICYCLES

Nestled in the rolling hills of the quiet small town of Waterloo, Wisconsin, not far away from the hustle and bustle and bike rack-lined walks of UW-Madison, is the Trek USA headquarters. Trek Bicycle, the birthplace of many bikes owned by UW-Madison students, is a world leader in quality bicycle manufacturing and a great source of pride for Wisconsin industry.

The Trek Bicycle Corporation was started in 1976 by a small group of people who believed that quality bikes could be made right here, in Wisconsin. Originally, the steel bike frames were imported, the components were added, and the bicycles were shipped out. But soon after, Trek began manufacturing their own frames. Today, all Trek bikes are

made in Waterloo, with the exception of seven models. These lower-priced steel mountain bikes, the 700 and 800 series, are designed in Waterloo, but manufactured in Taiwan to Trek's strict specifications.

Trek presently turns out 1000 steel and aluminum bicycles per day from its plant in Waterloo. Since all of these bikes are hand-made, a significant amount of work goes into manufacturing each bike.

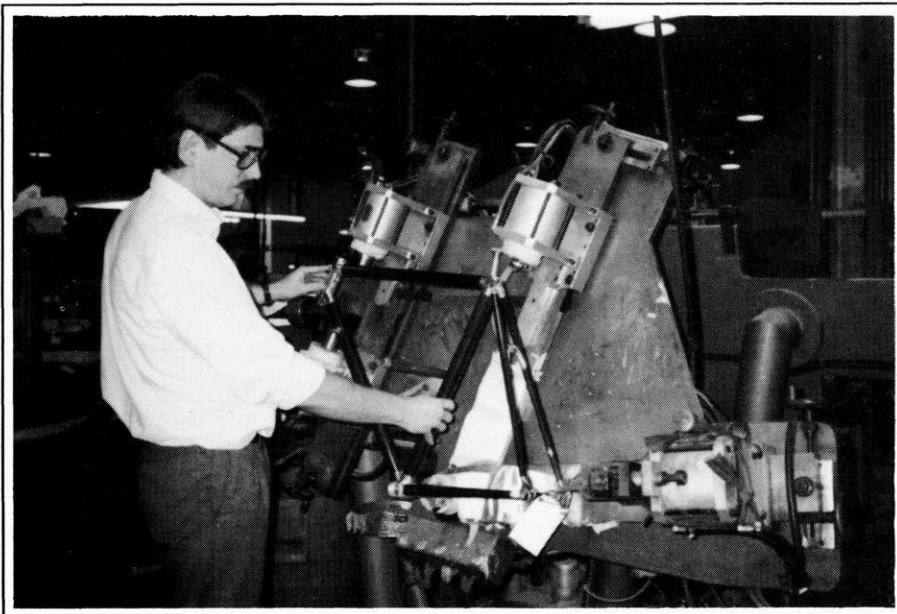
The first step in making the aluminum bikes is to prepare the frame surfaces for bonding. This stage entails several tedious cleaning processes, including sandblasting and chemical cleansing. Next, the tubes are assembled in a press-up machine, which

holds them while they are being bonded to the lugs. Once the parts are in the press-up, adhesive is applied, the frame is aligned and then pressed together. The adhesive used to bond the Trek bikes is heavy-duty aircraft/aerospace adhesive, the same used to hold together F-14 and F-16 fighter planes. Once the adhesive has begun to set, the frame is attached to an alignment fixture and removed from the press-up. The alignment fixtures, designed and manufactured by Trek, hold the frames in alignment while the adhesive sets. To set the adhesive quickly, the frames are put through a low-temperature oven. The oven is only about 150 degrees Fahrenheit, because high temperatures would damage the aluminum frames. Product Engineering Manager Wes Wilcox stated that the oven is like a "very hot summer day", and pointed out that a person could walk through it—if he or she really wanted to.

After the bonding process is finished, the "little pieces," such as the water bottle mount, are added to the frame. Then the frames are again cleaned, and the joints are smoothed out. Once this step is completed, one cannot tell where the bike was bonded or that the bike was ever bonded.

Once the frame is structurally perfect, it is sent to be finished. The surface of a Trek bike is finished in three steps. First, primer is applied, then pigment, and finally a clear coat. After the finish dries, the frame is sent to the final assembly line, where the components are added and the frame becomes a bike. The bikes are partially assembled into "short packs", and shipped out to Trek distributors.

The steel frame bicycles are manufactured in a similar manner. The difference is in the construction of the frame. The steel tubes and lugs are brazed instead of bonded. Trek bikes, unlike many other



Product Engineering Manager, Wes Wilcox, demonstrates how a bike frame is placed into a press-up machine for bonding.

steel frame bikes, are not welded. According to Wilcox, "This lug construction makes a stronger end product, and is more desirable for the long haul." After the frame is brazed, it is dipped into a series of tanks filled with chemicals to remove all of the residue remaining from the brazing process. After this step, the steel frames are sent off to be finished in the same manner as the aluminum frames.

Surprisingly, for such a high-tech plant, not a lot of automation is used in manufacturing processes. For Trek, hand-made means hand-made. The only signs of automation are paint robots and rim robots. Even these robots perform under the direct supervision of human workers. For example, the rims are hand-built, then sent to the rim robots, which tighten and align them, and are finally hand-checked by another worker. This hand-made philosophy assures quality bicycles.

People everywhere are becoming aware of Trek's commitment to quality. As a result, the company is expanding rapidly. A large addition to the Waterloo plant was just completed, increasing the production capabilities and creating new jobs. Trek is also expanding in Europe and even Japan. To date, there are six Trek-owned distributor bases outside of the U.S.

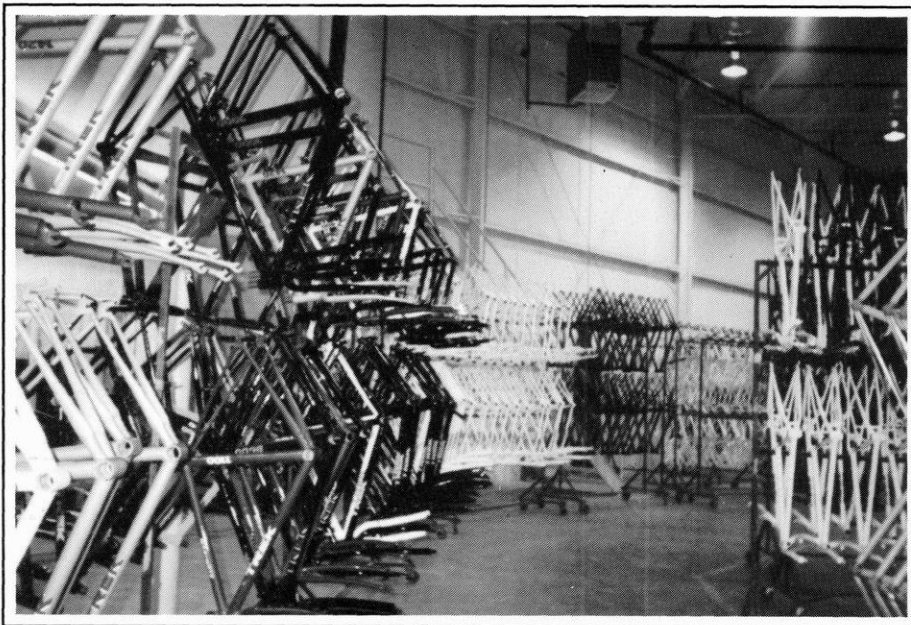
In addition, Trek recently introduced Jazz Bicycles, a new line of mountain bikes for the whole family. These brightly colored bikes range from the adult Voltage model in bright yellow to the children's Wizard model in "sparkle pink." These reasonably priced bikes are sure to be a hit.

Even as Trek gets larger and more worldly, their roots will remain in the small town of Waterloo, Wisconsin. Trek bikes will proudly wear the "made in the U.S.A." label, and more specifically, "hand-made with pride in Wisconsin." ■

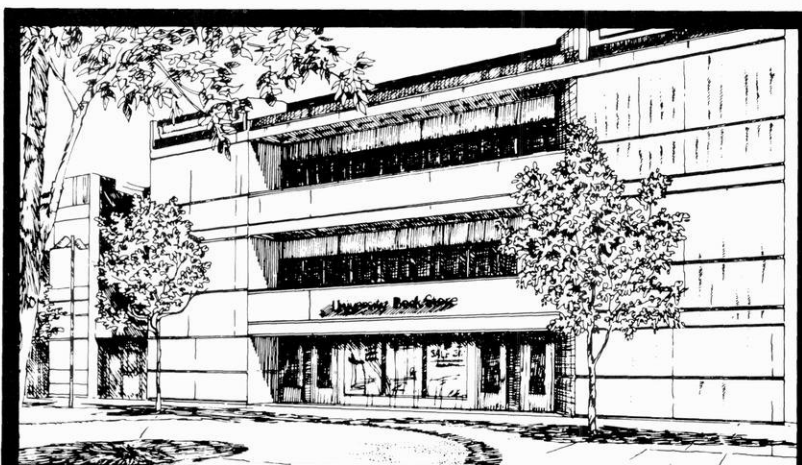
Photos by Amy Damrow

AUTHOR

Amy Damrow is a sophomore in Industrial Engineering. Her favorite sport?? Volleyball, basketball, running, and bicycling...



Trek bike frames waiting to go through the final assembly line.



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ELECTRONIC TAX FILING GIVES RAPID RETURNS

In our fast-paced, technological world, people have come to expect quick service, whether it be from warming food in the microwave, sending memos across the world via the fax machine, or now, getting their tax refund from Uncle Sam by means of electronic filing.

Electronic filing is a method by which qualified, independent, tax-preparing companies use a computer to

"The selling point of this service is the ease of getting the money."

send tax return information through telephone lines directly to the Internal Revenue Service. By using electronic filing, the taxpayer gets the refund in four weeks compared with the usual seven to eight weeks.

Electronic filing must be done by an independent tax-preparing company at present, according to Barbara Kerr, Public Affairs Officer of the Milwaukee District of the Internal Revenue Service. One such independent company is H & R Block.

The H & R Block office located at South 27th Street in Milwaukee started using electronic filing two years ago after doing some research. "We did survey studies in this area to see if there were enough people who received refunds," says Dorothy Edwards, a H & R tax preparer.



Some forms such as "married filing separately" cannot be filed electronically, but most of the commonly used forms such as the 1040EZ, 1040A and 1040 can. Also, the size of the software is limited, so it is incapable of handling too many of one type of schedule, according to Edwards.

If a client wants his or her taxes filed electronically, the tax preparer would have an interview with the client to get the necessary information in order to fill out the tax form, says Patty Johnson, a customer service representative at H & R Block.

Then, the form is sent to the H & R Block district office where the information is put into a computer and sent to the IRS. The IRS sends a receipt to the taxpayer confirming that it has received the return. The taxpayer also has the option of having the refund deposited directly into a checking or savings account.

Companies can set whatever fees they wish to process a return electronically. "The fee for the service usually ranges from \$15 to \$40, depending on the company," says Kerr. H & R Block charges \$25 for electronic filing if it

prepares your taxes. Tax preparation can range from \$20 to \$40. Otherwise, the fee is \$35 if a client brings in a prepared form because the tax preparer has to review the form for accuracy and conduct an interview with the client.

"Most people make mistakes on their tax forms. I had one client who said his form was perfect because his accountant had done it, but actually he left out an entire schedule," relates Edwards.

If 28 days is still too long to wait to receive your refund, then perhaps H & R Block's Rapid Refund is more your style. Rapid Refund takes six to nine days to get your money. Your taxes are filed electronically, but Rapid Refund essentially is a loan from a bank, says Johnson.

The bank lends you the exact amount you expect to receive from the government. Then, the bank receives the refund directly from the government. In order to qualify for a Rapid Refund, you have to be getting a refund in the range of \$300 to \$3,000 and not owe any back taxes, child support or alimony.

There is a \$33 bank fee added onto the \$25 electronic filing fee. You must fill out a loan application form, and then the bank must approve the loan. If the bank denies the loan, your taxes are still filed electronically.

"It usually takes six to seven days for the bank to clear the application. You know something is wrong if it takes longer," says Edwards. Edwards points out that the advantages of electronic filing are that you get your money fast with Rapid Refund, and the return is accurate because the computer reviews the form and spots any errors.

"There is a 20 percent error in filing returns on paper contrasted to a two percent error using the computer," says

Kerr. Kerr adds that electronic filing is also advantageous to the IRS since it eliminates the manpower time involved in sorting tax returns and entering information onto magnetic tape. Electronic filing puts the information immediately onto magnetic tape and

costs two to three cents per return while the old way costs 68 to 70 cents," says Kerr.

On the other hand, the fee charged by the tax-preparing company is a disadvantage, but "the service is justified in charging fees," according to Edwards. Other disadvantages, says Edwards, are "unwelcome surprises such as when you think the client is in good stead, but he's actually delinquent in child support or some other thing." Edwards warns customers to be honest with her because "dishonesty won't hurt me, it'll only hurt the client because sooner or later the government will catch onto the lies."

"Computer crime can be a problem with a system like this since it's harder to steal papers," says Mark Barnard, a Marquette University computer science pro-



fessor. Barnard also warns that total dependency on the system should be avoided because, if it fails, there is no back-up system. However, he adds that anything that cuts down on paper is good and saves money and that the economic benefits of the system outweigh the disadvantages.

Surprisingly, the service is not used primarily by wealthy people. Well-to-do people don't need money fast. It's the lower income people who need the refund money for repairs on the car or to pay for an airline ticket so they can go on vacation, notes Edwards.

Barbara Smith, an H & R Block customer for 10 years, came to pick up her

Getting the refund in "six to nine days is better than six weeks..."

Rapid Refund check before leaving on vacation. Smith says she likes the service because getting the refund in "six to nine days is better than six weeks and you don't have to pay beforehand either. Payment for fees can be deducted from the refund, so it's painless and provides a lot of help to people who need the money."

Edwards adds that "it's not like a credit card where people have to pay later. One man couldn't pay for the fees up front, so I said he could pay when he got the refund in six to nine days." The selling point of this service is the ease of getting the money, she says. ■■

Graphics by Dave Ljung

AUTHOR

Nazima Jaffer is a journalism student and a Technical Communication Certificate candidate. Nazima, who is anxiously awaiting the arrival of her tax refund, says one of her favorite sports is tennis.

"The fee for the service usually ranges from \$15 to \$40, depending on the company."

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Need A Little Spending Money?

How does \$420,000 sound? That's what the UW Fusion Technology Institute is getting from the U.S. Department of Energy to work with three major industrial firms on the development of commercial fusion reactors. In conjunction with AVCO, Bechtel Corporation and General Atomics, the institute will develop reactors which produce electricity by means of powerful lasers or beams of heavy ions, a process called inertial confinement fusion. Professor Gerald Kulcinski, director of the institute, feels that it is necessary to have industry lead such studies in order to ensure the commercial acceptability of inertial confinement fusion.

Where's The Party?

If you missed the free beer and soda for engineering students at the Rathskeller in December, don't miss the 'new and improved' pre-finals event being planned for the end of this semester. Like last semester's 'Power Happy Hour', this semester's event will be funded by several Polygon-member organizations. Keep your eyes open for flyers publicizing the event.

ENGINEERING BRIEFS

by Mike Waters

Eliminating Registration Aggravation

Two years ago, the UW-Madison Registration System made a change from 'archaic' to 'angelic' by offering the time- and sanity-saving convenience of touchtone registration. Registration for the fall semester promises further convenience, not through additional changes in the actual process, but through a change in the month of the year in which it takes place. Immediately after Spring Break, registration materials will be mailed to students at their campus addresses. On April 8, registration for the summer and fall semesters will begin. By registering for classes while still on campus, students will be able to consult with an advisor immediately before and during the registration process. Students will then know exactly what classes they will have in the fall and be able to pursue their summer plans uninterrupted and worry-free. Also for the first time ever, new freshmen will register for fall classes during SOAR.

Be A Sport, VOLUNTEER!

It's not too late to volunteer for EXPO '91. Many volunteers are still needed to help with the events and activities of the EXPO '91 - 'Sports and Engineering' weekend, April 19-21. So if you're looking to add a little volunteer work to that otherwise perfect resume, contact Lynn Graber (255-0653) or call the EXPO Office (262-5137).

Your Opinions Count

This past fall, Polygon sponsored the first Engineers' Survey to get students' evaluations and opinions of the UW College of Engineering and its facilities. The results of the survey were published in a report to the Academic Planning Council of the College of Engineering, which included almost all of the personal comments made by students. If you missed participating in the fall survey and want 'your' voice heard, you may have another chance this spring. Polygon is planning a similar survey and expects a much greater response as the survey is to be passed out by professors in various engineering classes.

Another UW 'FIRST'!

After a heart-stopping UW hockey team won the national title last season, many thought it would be a long wait for another UW 'first.' Well, hockey fans may have to wait for another championship, but fans of the UW College of Engineering can cheer that UW COE researchers, in collaboration with Sandia National Laboratories, have developed the world's first high-temperature superconducting transistor. The device is used to control electrical current and can operate at higher sub-zero temperatures than previous superconductors. The director of the project, UW alumnus Jon Martens, and his colleagues hope the device will lead to more advanced electronic products.

Welcome Back, Shaun!

Approximately 70 UW-Madison students were called up for duty since the crisis in the Persian Gulf began last August (including Shaun Burke, a *Wisconsin Engineer* photographer). About one-third of those students were in combat units in Saudi Arabia. The rest were in weaponry supply or medical support units. Hopefully, all of them will be rejoining us here at the UW in future semesters.



DR. NICK HITCHON

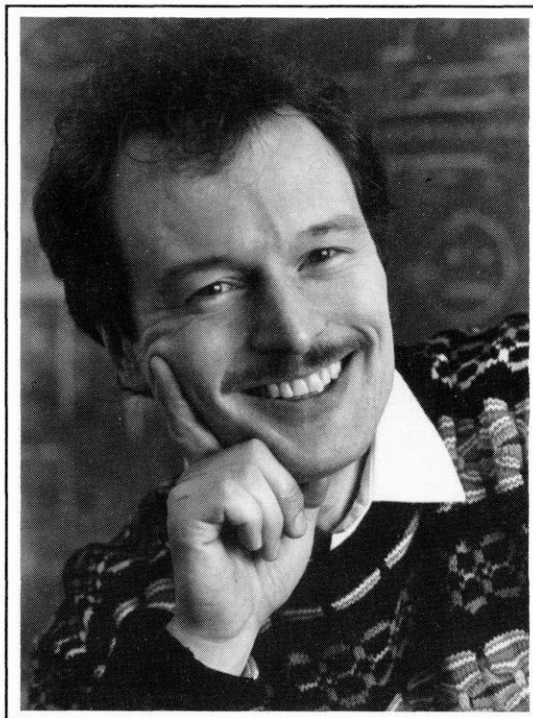
PART OF THE 'BIG PICTURE'

Seeing the 'big picture' is a priority of a very personable associate electrical and computer engineering professor- Nick Hitchon. And, there are actual portions of his life that may be seen on the 'big picture' - on film that is - as he is part of a British documentary about society which focuses on the lives of various people who grew up in Britain.

In 1963, Michael Apted, director of *Gorillas in the Mist*, *Gorky Park*, and *Coal Miner's Daughter*, and his crew filmed interviews of fourteen 7-year-old British children of differing social backgrounds. Hitchon was chosen because he represented the lower class. "I was very talkative even then and had no fear of talking to the camera. I was actually only six at the time, so I fit right into the mold they wanted of a rather stupid seven-year-old farm kid."

Every seven years since that time Hitchon has been visited and filmed by Apted and his crew - the most recent being last January here in Madison. Though it is a novel conversation piece, Hitchon reveals that having your life recorded on film is not simply a glamorous photo album. "It's like a photo album that is open for anyone to see. A few pictures shot in a day cannot accurately depict a person's life," explains Hitchon.

The director can film and edit the scenes to produce whatever overall effect he wants, which is usually whatever makes for good TV, not necessarily "real life". For example, the crew filmed Hitchon and his wife at Madison's Westgate Mall because big malls aren't common in England. Hitchon relates his experience, "They said, 'Pretend you're shopping for these clothes,' and filmed us looking through some neon teen store that I would never have shopped



Nick Hitchon is a professor in Electrical and Computer Engineering.

at. Meanwhile, they are dubbing over a voice saying, 'Nick came to America for a thirty-thousand dollar salary...' which sounds like a phenomenal amount to the English and portrays me as being a very materialistic person."

Hitchon went on to admit that he is not really prone to spend a lot of money on anything and proceeded to criticize the stylish clothes he was wearing. He explained that he is really a "jeans and T-shirt kind of guy".

Hitchon has broken the anticipated mold of a poor rural farm kid by obtaining his M.S. and Ph.D degrees at Oxford, specializing now in numerical modeling of applied physics in electrical engineering problems. He came to Wisconsin eight years ago and has been a UW professor for six years.

Yet, he continues to strive for the 'big picture'. He does not consider

himself, by any means, to be as big a success as the documentary portrays him to be. He strongly believes in always trying to increase one's knowledge and avidly encourages students to continue their education. "By going on to graduate school and getting a M.S. and a Ph.D, you expand your perspective. You can do more and see more. You come to a point where the things you've learned start meshing together. You can start to focus on what's important...the big picture." Consistent with his picturesque viewpoint on life, family is very important to Hitchon. His wife is currently earning her M.B.A. here at the University of Wisconsin-Madison and will soon be hired as an Associate Journalism Professor. Hitchon is also often seen around campus with his 18-month-old son, Adam. He

puts a considerable amount of effort into spending time with his son, who enjoys snacking on popcorn and juice with his dad at the Union.

Hitchon is a 'delightful chap' who is quite aware of the society he lives in and enjoys interacting with his students and peers.

So the next time you're watching a movie, remember 'the big picture'. Who knows, the life of Nick Hitchon may flash before your eyes! ■■

Photo courtesy of UW-News & Information Service.

AUTHOR

Amy Ricchio is a junior in industrial engineering. When she's not busy with homework, she can be found playing a mean game of tennis.

TENNIS SHOE TECH

"It's gotta be the shoes!"

— Mars Blackman, Nike Spokesperson

How many times have your parents told you, "It's not the shoes, it's the person who wears them"? Somebody please inform the shoe industry.

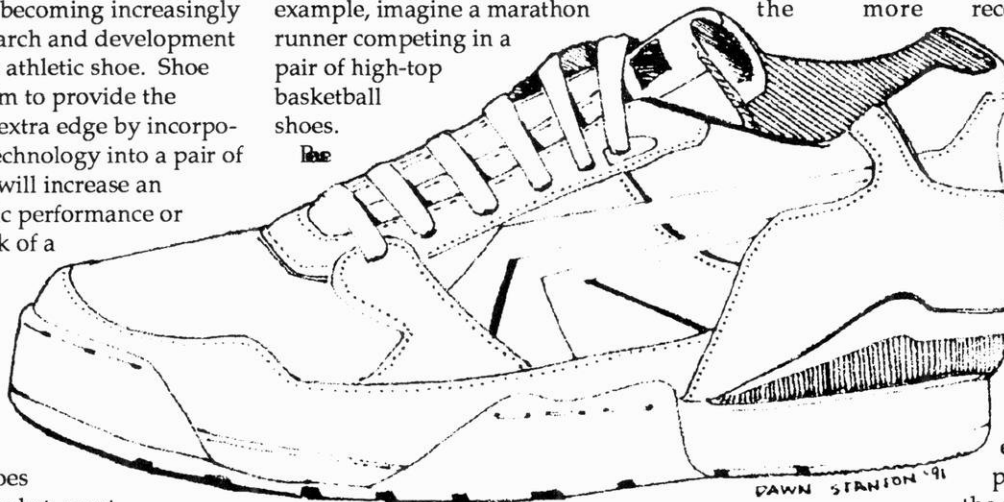
With more and more people exercising regularly, athletic shoe manufacturers are becoming increasingly dependent on research and development to produce a better athletic shoe. Shoe manufacturers claim to provide the consumer with an extra edge by incorporating some new technology into a pair of athletic shoes that will increase an individual's athletic performance or help reduce the risk of a serious injury.

But with the lack of standard athletic shoe performance tests and over 200 million different pairs of athletic shoes currently on the market, most models changing yearly, the concept of a better shoe is not so clean cut. A consumer can easily become lost in an endless array of shoes displayed on the wall of the shoe store. The age of thick rubber soled canvas sneakers has given way to the lightweight compression molded shoes of today.

In modern day athletic shoe manufacturing, two important factors stand at the forefront of design and construction: cushioning and stability. A good athletic shoe must absorb the shock produced upon impact with the ground while supporting the foot and protecting it against extreme sideways or twisting movement. At the same time, the shoe

must also provide flexibility, to accommodate normal foot motion, and durability all at a reasonable cost.

Shoe manufacturers must also consider the type of activity and the kind of movement the consumer will be involved in. Even though 80 percent of all athletic shoes sold are used for nothing more than walking to class, all aspects of shoe construction must revolve around the intended purpose. For example, imagine a marathon runner competing in a pair of high-top basketball shoes.



shoes designed mainly for one sport only appeal to a limited portion of all athletic shoe buyers, a new type of shoe is emerging that is geared toward those who cross-train. Shoe manufacturers produce these shoes for people who are involved in several different activities and find it difficult to carry around or afford several different pairs of shoes. These shoes generally have the foot support of a basketball or tennis shoe mixed with the flexibility and cushioning of a running shoe.

Perhaps the best indication of the number of different shoe technologies is the number of different shoe manufacturers. With most of the larger athletic shoe

companies producing over one hundred different types of shoes, excluding colors, the ability to select the best shoe may require as much practice as developing a good jumpshot or mile run time. It is not something a consumer should attempt to do while looking through a shoe store for 15 minutes prior to buying a new pair of athletic shoes.

In the interest of introducing different athletic shoe technologies, some of the more recent developments

of the larger companies must be discussed.

Arguably, the most advertised line of athletic shoes on the market is the Nike Air line. Nike has developed and implanted pressurized air, encapsulated in polyurethane, into the soles of a

majority of their shoes. These air pockets provide a lightweight cushioning that maintains its original form throughout the entire lifetime of the shoe. They also offer added stability by distributing the force of the impact across a greater area of the foot. The air pockets are located in the midsole section of the shoe and stretch from the heel to approximately the ball of the foot.

Nike also manufactures some of its top of the line athletic shoes with Hytrel support straps, a flexible thermoplastic developed by DuPont, and Durathane toe wraps to help prevent shoe breakdown under quick start/stop conditions. How's that for cushioning, stability and

support?

Directly competing with the Nike Air line is the Reebok Energy Return System. Shoes from the ERS line offer encapsulated hollow tubes of Hytrel, again in polyurethane, also implanted in the midsole of the shoe. These implanted tubes are not only designed to absorb shock but also to replicate and return the energy produced upon impact with the ground. Hytrel is another material that maintains its shape well after prolonged use. These materials make shoes more durable than older, less expensive shoes with foam rubber soles.

Since the concept of energy return is fairly new and unexplored, it has its opponents — composed mainly of other shoe manufacturers. Many of them feel that the idea of energy return from an athletic shoe is not possible since the shoe needs to absorb the energy of impact at the heel and transfer this energy to the toe for push-off. Most materials implanted in the midsole of the shoe are exclusively for shock absorbancy. From another viewpoint, only the competitive athlete would benefit from energy return since most athletes exercise to expend energy and do not need it returned.

Also gaining much attention these days, if not for innovation then for price, from the design department of Reebok is The Pump. These hi-top athletic shoes offer a built-in air pump, located in the tongue of the shoe, that allows an individual to customize shoe fit and support by varying the amount of air held within the shoe. These shoes cost approximately \$170 per pair.

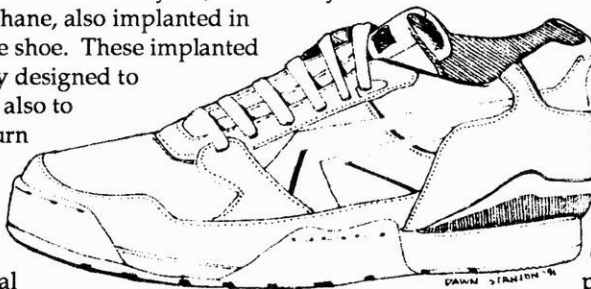
Another shoe company that

features a material implant in the sole of the

shoe is Asics, formerly Tiger. In their Gel line, Asics implants a silicone gel, encapsulated in a lightweight semifluid developed in Japan, in the midsole region of the shoe. This concept is also intended for lightweight cushioning that lengthens

the life of the shoe. Asics produces Gel athletic shoes for all different types of sports.

Shock absorbancy has also found its way into the soles of Hi-Tec's Air Ball



Concept line of athletic shoes. The ABC shoes feature a polyurethane encapsulated cylinder of pressurized

air that is not only designed to compress upon impact but also regain its shape upon lift off. A large cylinder contains the air directly under the heel of the foot.

Brooks has taken the aspect of cushioning one step further in developing their HydroFlow line. These athletic shoes feature a sole where pressurized silicone fluid flows between two chambers, one under the heel and the other under the ball of the foot. When the heel lands on the ground the silicone fluid is forced from the back chamber to the front chamber and vice versa when the athlete pushes off on the ball of the foot. The fluid flow from the toe chamber to the heel chamber is carefully restricted so the liquid will not absorb and dissipate the energy from pushing off the ball of the foot.

Other companies have tried cushioning the foot from heel to toe while at the same time offering additional support and stability for the entire foot.



Saucony Azura has manufactured a Torsional Rigidity Bar made of Hytrel and Kevlar, both DuPont products, in the sole of

their shoes that keeps the foot on a straight course while offering flexibility and rebound over the entire length of the foot.

In a similar design, Turntec also manufactures bars of superball material

into the midsole of their ZO3 athletic shoes. These bars lie in the midsole of the shoe under the back of the foot.

Since the body of the athlete can vary in so many different ways, the athletic shoe needs to be designed with the best guess at who will be wearing a particular pair of shoes. A larger person may need all the support possible, while a runner with a high arched foot may need to purchase extra arch support inserts. Other people strike the ground with different parts of their foot thus requiring more cushioning and support in different areas of the shoe.

Shoe manufacturers try to design shoes that will fit comfortably while supporting and cushioning the foot through adverse exercising conditions. Since test driving a new pair of sneakers is limited to the shoeroom of the shoe store, advice from store employees and friends is the best buyer's guide.

"There is no one best shoe," explains Mitch

Mroz, a salesman at Movin' Shoes of Madison and a physical education

instructor at UW-Madison. In buying athletic shoes, he adds that athletes need to "understand the type of runner you are, as well as your biomechanics and your foot anatomy . . . You need to go into the store and try on the most different pairs possible to determine which shoes fit your foot the best." ■

AUTHOR

Dan Grellinger is a junior in Electrical and Computer Engineering. When the weather gets warmer, you can catch him playing football with his friends.



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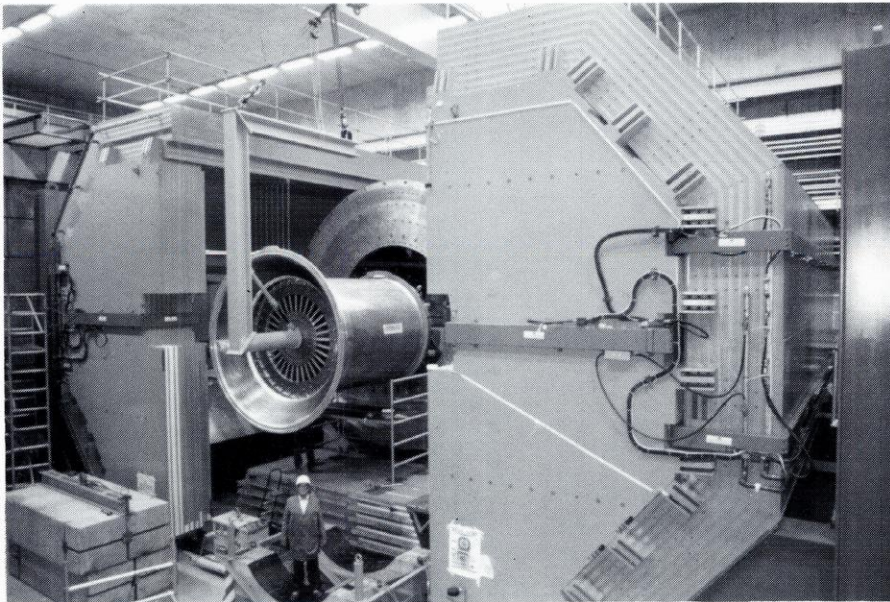
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