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Environmental Issue

Ten Interesting Engineers...

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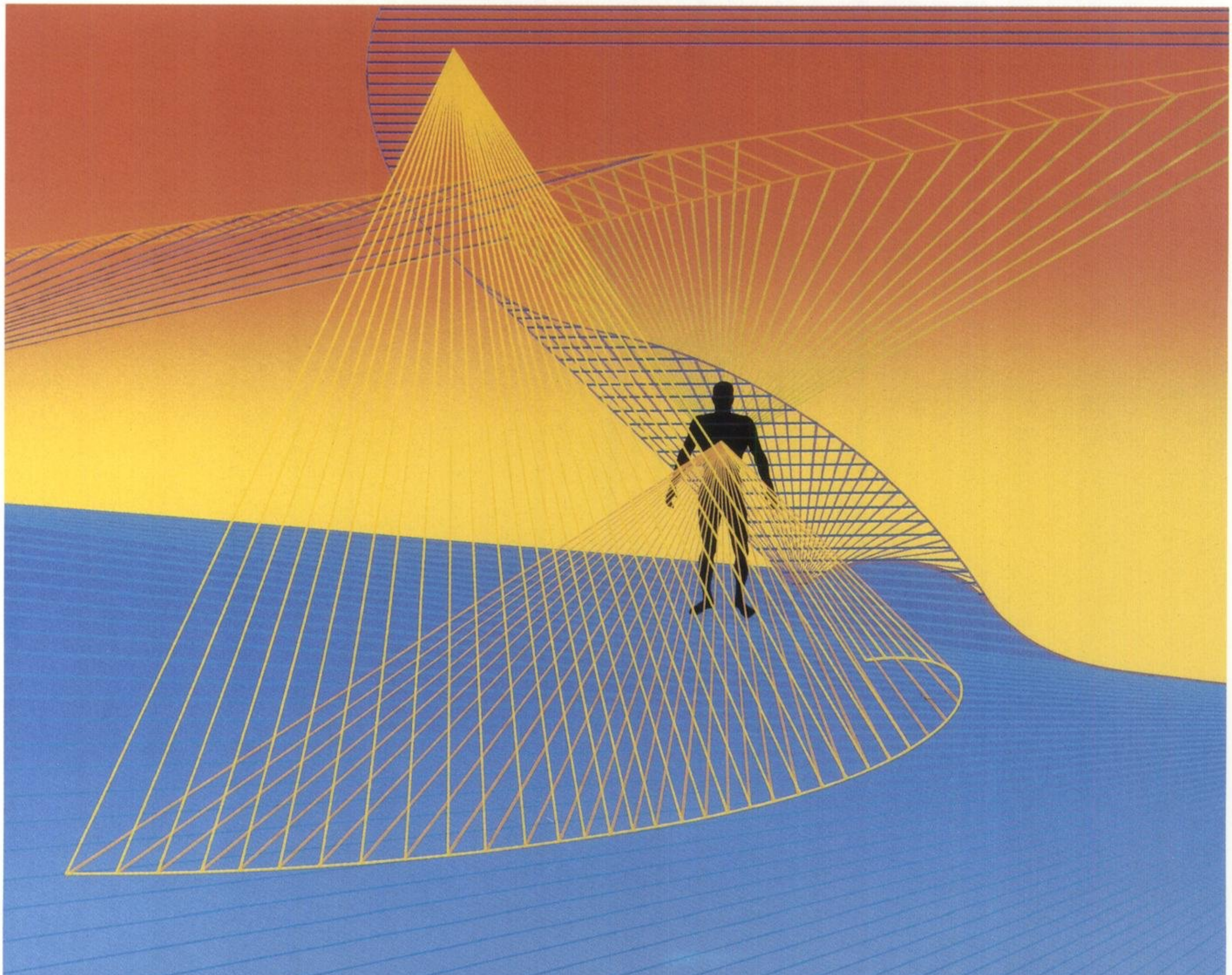

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wisconsin engineer

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Editorial

by Darin Buelow
and Don Korjenek

Accidents call for more stringent plant rules

The recent disaster in Bhopal, India, where hazardous leakage from a Union Carbide plant killed more than 2,000 people demonstrated the extreme dangers of toxic substances. Two more recent plant accidents signal an alarming need for tighter regulations and a greater involvement by engineers.

On January 2, 1988 an Ashland Oil Company storage tank in Floreffe, Pa. was being filled to it's capacity of 4 million gallons of diesel fuel. The tank suddenly ruptured, spilling 3.8 million gallons of fuel almost immediately. The earthen dike constructed around the facility held, but could not contain some 860,000 gallons that rushed into the nearby Monongahela River. The spill flowed downstream to Pittsburgh, and subsequently contaminated the Ohio River until an ice jam near Stubenville Ohio delayed the flow.

Inside of 24 hours some 23,000 people in the Pittsburgh area were without water, and another 750,000 were forced to ration what water they had. The disaster shut down much of the industrial operations in the Ohio River Valley and inflicted untold ecological damage. While the spill occurred in the wintertime, thus saving much of the river's ecosystems, the disaster still ranks as the worst inland oil spill in U.S. history.

The engineer's role in such a disaster involves not only tank design, building, and inspection, but also clean-up procedures and equipment. The floating rubber boom often used to contain the spill and the vacuum hoses that skim it off the water work well in lakes or in the ocean, but river flow proves too turbulent. The mixing caused by this turbulence left nearly 90 percent of the Ashland spill unrecoverable. The fast moving current simply pushed the oil past the five booms that were deployed in clean-up attempts.

Another plant accident in Switzerland on November 1, 1986 further shows the need for tougher laws and technological advances. A fire at Sandoz, a Swiss chemical firm, led to approximately 30 tons of chemical pesticides being washed into the Rhine River. The blaze began just after midnight, and the dangerous chemicals were washed into the river by the firefighters' water. The disaster has caused long term damage beyond the half-million dead fish and eels. Originally, experts estimated it could take 10 years for life in the river to recover. While immediate danger to the public was averted, it is the long term effects that worry scientists and government officials.

As in the plant accidents at Chernobyl and Bhopal (Union Carbide), many European countries fear for what damage may have been done. The accident re-ignited a frenzy of political pressure to tighten regulations on chemical plants. The European Economic Community (EEC) has adopted tighter rules for handling toxic wastes, but Switzerland does not belong to the EEC. There are also millions of small storehouses outside the chemical industry that are difficult, if not impossible, to control in Europe.

Furthermore, a lack of available technology with regard to clean-up served to increase the severity of the accident. Efforts to dredge pollutants bound to mud on the bottom of the Rhine were not completely successful because the top layer of sediment proved to be immobile. Also, a vacuum dredger is too large for a River such as the Rhine. For this reason, divers with smaller vacuum dredgers were used— a much slower process. Clearly, equipment is needed which can handle toxic spills quickly, to lessen the damage.

The issue of plant accidents has become very serious in recent years. The oil spill on the Monongahela and the chemical spill on the Rhine are just two examples of insufficient technology and inadequate regulations regarding such matters. As is often the case, it takes disasters such as these to make people realize the need for change. Engineers in particular will play an important role in the design of equipment and storage facilities, as well as many other areas. Governments and Industry will also have to work together toward tougher regulations regarding safety, inspection, and accident reporting. Hopefully, with these improvements, future accidents can be handled more efficiently. Maybe they can be avoided altogether.□

Let's get small!

Russell Labs' Scanning Electron Microscope

by Craig Fieschko

I spent a half hour on a moth's head today. I wandered around in the forest of hairs that surrounded its compound eyes, looking for potato chip bags or rusty beer cans or anything that would tell me that someone had been there before me. It was obvious that very few people had seen this forest before. All I found was a few globular objects that might have been fungus, and bits of strange, flaky rubble. Moth dandruff, I thought to myself as I zoomed off the surface of its left eye, and back to the world where moth eyes are so small as to be almost nonexistent.

How'd I get there, you ask? No, I wasn't under the influence of any controlled substances. I didn't get there using an optical light microscope; I couldn't, because light does funny things when you're only as tall as its wavelength. I got there using a Scanning Electron Microscope (SEM), more specifically— the Hitachi S-570 SEM, located in B-44 Russell Laboratories here on campus.

Not many people know about the SEM at Russell, or that it's available for anybody to use. That's why I'm telling you about it. There's a nominal charge for scope time because the SEM is rather expensive to run (it's far more expensive if you want to buy your own), but the specimen preparation and consulting are free. This is the important part if you know as little about the SEM as I used to. Melissa Curtis and Sandy Zetlan were my friendly SEM specialists; they helped me safely onto the moth's eye without getting lost or breaking anything. Actually, the SEM was surprisingly easy to use. By the end of my session with the SEM, I could even get around the moth by myself. Let me tell you about my session from the start.

First, we had to prepare the specimen. I brought along a bunch of hair from my week-old haircut, so I thought this might make an interesting specimen. A SEM specimen has to be made electrically conductive because it gets shot with a beam of electrons; if the charge doesn't have anywhere to flow to, it can build up and burn the specimen. Nobody likes the smell of burning hair, so a bit of silver paint was used to give the hair a conductive path to ground. A specimen can also be made more conductive by putting it in a device that vaporizes gold with a high-current arc and coats the specimen with a thin gold film. (Yeah, I was thinking of other uses for this too, but the gold coating's so thin you can rub it off on your fingers.) If the specimen wasn't grounded, there's still not much danger of starting a fire in the (very highly expensive and big big trouble for anyone who wrecks it) SEM because the specimen chamber is drained of air. This causes another problem, though; any specimens that contain water will rupture and throw specimen bits all over the specimen chamber as the water boils off into the vacuum. It is therefore a very good idea to dry any water-bearing specimens.

Backscattered Electrons are the higher-energy, coffee achievers of the SEM working world.

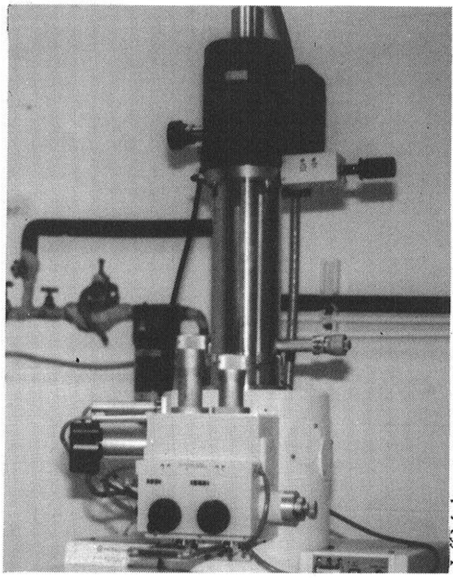
This is all very nice, you may say, but if the specimen in question is a grape, isn't it going to end up as a raisin when it gets dried? This would be the case if it wasn't for another neat machine with a big name: the Critical Point Drying Apparatus. This nifty bit of technology replaces the water in a specimen with carbon dioxide to avoid any unpleasant shrivelling effects.

After we prepared the hair specimen, we were finally ready to start. We put the mounted specimen in the specimen chamber (which is six inches in diameter for the Hitachi and very large for a SEM) and pumped out the air. Shortly afterwards I was viewing my own hair, two thousand times larger than life. It looked a lot like you'd expect hair to look if it was cut off, blown up two thousand times, and put in front of you for inspection. A few split ends, but no cooties. Overall, I would say that hair is a very boring specimen. Luckily the lab has a lot of spare prepared specimens, or I'd have been stuck wandering around my hair and I'd have nothing to talk about. I mean, hair is a nice place to visit, but I wouldn't want to live there.

So that's how the specimen preparation works, but how does the SEM work? I'll explain it from the very first step. Pretend that you're an electron that wants to help some dedicated young engineer analyze a new microchip. (It takes a little bit of imagination, but if you practice for a while, it'll come naturally.) You eagerly run up the power cable supplying the SEM and since you want to be in the center of all the action, you take a turn along the circuit that supplies the electron gun. It boosts your electric potential anywhere up to 20 keV (kilo electron-volts) and throws you down a tube towards the specimen, sort of like an amusement park ride for electrons. For your convenience, the engineer has drained the tube and specimen chamber of air so you aren't bumping into any air molecules. You start to feel a pushing sensation. Apparently, you weren't travelling in a very straight beam with the rest of your electron buddies, so an electromagnetic lens gave you a little shove so you could get back into the crowd. The engineer varies the excitation of the lens so he can push the electron beam you're in to some desired diameter. You continue traveling down the tube, passing one or two more electromagnetic lenses as you go, until WHAM! You hit the specimen. You've done your job and now you can run along some conducting path (provided by the thin coating of gold, for nonconducting specimens) to ground where you can take the rest of the day off and go to the beach or watch TV or something. Other electrons will follow you as the electron beam sweeps over a wide area of the specimen to be sure the engineer gets information over a wide area of the specimen instead of just the one discrete point you hit.

But wait— how does the engineer get the image of the specimen on the screen? Well, it turns out that when you applied for the job in the electron gun, you got a cushy managerial position as a Primary Electron, and you had other workers do the job of bringing the image to the engineer. When the electron beam strikes the specimen, it causes the specimen to let out a number of different emissions, all of which can be used to find out different characteristics of the specimen to put on the screen. If you work in an electron beam as a Primary Electron, the emissions working under you are Secondary Electrons, Backscattered Electrons, and X-Rays.

Secondary Electrons make up the bulk of the work force in the specimen. When the electron beam sweeps over the specimen's surface, secondary electrons pop out with an average energy of about 4 eV (which is not very high) and the engineer uses a positively-biased collector to pick them up and put information on the screen. This is done by taking the electrons from the collector to a scintillator. The scintillator puts out an output light signal that is linearly proportional to the energy of the secondary electrons. This signal is then sent to a cathode ray tube that produces an image by sweeping the signal across a screen, producing an image in much the same way your television does. The secondary electrons come out of only the first few nanometers of the specimen, and since this essentially comprises the surface layer, these electrons are good for getting information about the topography of the specimen. If you get a managerial position in the electron beam, you'll get the secondaries to give the engineer a picture of the specimen's surface.


Jeff Molter

The Scanning Electron Microscope

The engineer will get an incredibly detailed picture of the specimen's surface; it will look almost exactly like a real-world image, with a 3-D effect that gives a remarkable depth-of-field quality to the picture. This happens because the angle of incidence between the electron beam and the specimen's surface increases as the specimen gets farther away. It turns out that when the angle of incidence is increased, the number of secondaries that are knocked out by the electron beam increases, almost as if the electrons in the beam were better able to "slip under" the surface layer and goad more secondaries to work. Since the screen image signal will vary linearly with the number of secondaries produced, when the electron beam sweeps over an area that is farther away (and thus has more secondaries popping out), the image signal on the screen can be made to look farther away. This nifty 3-D effect explains the popularity of the SEM for looking at cells, fracture surfaces, and of course, moths. In fact, the SEM is sometimes used to get 3-D hard-copy pictures of specimens. This is achieved by taking two pictures of a specimen at slightly different tilt angles. When each picture is presented separately to the right and left eyes, the parallax in the pictures causes the brain to interpret them as a single, 3-D image. These "stereo" pictures can be used to make measurements of the surface relief; one could accurately measure the width of a moth's eye, if he wished.

The secondaries can also be used as a kind of remote-control voltmeter for electronics applications. If areas of a microchip are at different potentials (voltages), then the secondaries sent out from these areas will come out of these areas at correspondingly different energies, and the differing-potential area will be seen by the engineer with a different image contrast than the surrounding area. Thus, the engineer could find the voltages in the different components of the chip and perhaps find flaws that may exist without even touching the chip surface. The SEM can also mimic a sampling oscilloscope by taking screen images at the same frequency of a current being applied to the chip. Different areas of the chip will show their specific potentials (voltages) at that specific point of the applied current waveform, and if the screen image samples are taken at different points along the current waveform, the engineer can map out the voltage waveforms for different areas of the chip.

Backscattered Electrons are the higher-energy, coffee achievers of the SEM working world. These electrons come from as deep as a few microns from the specimen's surface, and since they have more than ten times the energy of the secondaries, they have the energy to push through the specimen from that depth and go to the collector. The number of backscattered electrons that pop out of an area of the specimen is a function of that area's atomic weight, so the image that will be seen by the engineer will show areas of different atomic weights with different contrasts. In this way, the engineer can map out areas of the specimen with different elemental compositions. This is very helpful in the field of metallurgy when one wants to find the microstructure of multiphase alloys, or in biological fields when one wants to examine specific areas of a cell. The area of the cell to be examined is stained with a heavy metal solution so when it is observed under the SEM it will stand out easily against the low atomic weight, carbon-based background.

The backscattered electrons can also be used to find the structure of a crystal's electron lattice. If the electron beam is sent to the specimen's surface at random angles, the backscattered electrons all emerge from the same approximate depth. However, if the beam should happen to be directed along a plane of symmetry of the crystal lattice of the specimen, the primary electrons will penetrate deeper before the backscattered electrons are emitted, and less backscattered electrons will escape to be collected. Therefore, the image contrast will change when the electron beam is pointed along a plane of symmetry, and by tilting the specimen the crystal lattice can be mapped.

X-Rays are also workers from beneath the specimen's surface; in fact, they come from within the specimen's atoms. Some especially energetic primary electrons (maybe you're among them) will transfer some of their energy to atoms in their path by ionizing the inner shell electrons. The atoms, none too pleased at having their electrons ionized, will respond by emitting X-rays to get rid of the energy they picked up. Since the X-rays that are emitted have an energy that depends on the distinct binding energy of the element they came from, these X-rays can be analyzed by an X-ray spectrometer to give the precise chemical composition of the specimen.

So it seems that your job as a primary electron doesn't involve much real work in bringing information to the engineer by yourself. Actually, if you get yourself a job in an electron beam in the electronics industry (which is a pretty good chance because half of all the SEM's made are sold for electronics applications) you can do some additional work producing Electron Beam Induced Currents. When the electron beam hits a semiconductor, it knocks some of the semiconductor electrons out of place, leaving a kind of "hole" in the semiconductor. The electrons tend to fall back into the hole, unless the engineer has applied an electric field to the semiconductor. If he has, the electrons that got knocked out are pulled in one direction along the field, and the hole travels in the other direction. How does a hole move, you ask? The hole moves by pulling another neighboring electron into it, so this neighboring electron leaves a hole, which pulls a neighboring electron into it, which leaves a hole... anyway, you get the picture. It's kind of a game of leapfrog for holes, which is none of your concern because you're pretending to be an electron. Since the flow of electrons (and holes) basically comprises current flow, you've just produced a miniscule (but measurable) current. Taaa-daaaah! Electron beam induced currents. Using this method, the engineer can produce currents in any desired area of the semiconductor and check for flaws without even plugging it in.

Those are the basics of the SEM functions. It is, as you have seen, a tad bit more powerful than the optical light microscope in the lab kit your mom got you when you were a kid. The SEM can reach smaller and smaller resolutions just by decreasing the area that the electron beam scans over. The magnification is only limited at the point where the scanning area gets so small that the resultant emissions get too small for the SEM to detect.

I strongly recommend trying out the SEM at Russell Labs; since a SEM purchase is a bit out of the range of most student budgets, this could be the only opportunity you have to operate one yourself. Some students use it for class projects, and some (like me) look at hair and moths and other neat stuff. Just get a few people together, gather some funky specimens, and head out there. You can set up an appointment with Sandy or Melissa at 262-1819. Now if you'll excuse me, I just found some belly button lint I wanna check out...□

TEN OF WISCONSIN'S ENGINEERING

ROY NILSEN ECE/4

UW marching band drummer

by Tony Wolfram, Shelly Hoffland, James Giefer and John Stangler

"Partying, screwing around, and just being off the wall used to be the major characteristics of this university," says Roy Nilsen, whose departure this May will symbolize the end of the University of Wisconsin's infamous reputation of being a big partying school. "We don't even get ranked in Playboy anymore," he says.

With the change in students' attitudes towards socializing and the increased drinking age, the campus life barely resembles what Roy experienced his freshman year. "Students don't have the same partying attitude anymore," he says. "Maybe the partying got too big here, but if people start getting too serious about school, it's going to change the whole attitude people have about attending school here and what employers think of the graduates. That's one of the things people look for in Wisconsin graduates—it's a good school that takes a lot of work to get through, but we know how to screw around."

One of the engineering firms Roy interviewed with said that Wisconsin graduates seemed to work better together in a group and looked at things differently. "It's not necessary to go out and get blind-stinking drunk, but you should try to get out of the house or library and be with different people," Roy said.

The last hope for retaining Wisconsin's status as a well-rounded institution of higher education may lay in the hands of the UW-marching band. Through their legendary fifth quarter antics after football games and obnoxious behavior at hockey games, the band provides a release from studying to the engineers that compromise over 40 percent of the band. Band members have a well-deserved reputation for throwing wild parties and being heavy drinkers. Because someone can announce a party and expect 200 band people there, some of their roommates refuse to let them throw parties.

Roy has contributed to the marching band's reputation over the last five years. At his Halloween party last fall, there was a 20-minute wait just to get into the house with all three porches and both floors full of people all night long. He also used his engineering skills to reconstruct a four-person beer-bong that had some flow problems and a lot of foam by using an old garbage can with four nipples stuck on the bottom. The breakfast he distributed to his percussion section on their bus trip to Michigan consisted of a doughnut encircling a

Most Interesting Students

bottle of Point beer. And at his last "Olympic" party, a luge run was set up using a sled, stopwatch, and their stairs. Athletes had to slam a beer at the top of the stairs before jumping on a sled that leads you to a shot of liquor to be swigged quickly at the bottom. Roy won the silver medal.

"If you don't have something else to do, you get real stale," he says, "and if you think too hard about something and are always thinking just about some problem or some project, you get in a rut. If you just get your mind off it completely for a night, by going to a party, for example, you'll wake up the next morning and have thought of something different. I always find that you come up with better solutions after you've been out screwing around having some fun, because if you're not getting anywhere, there's no use sitting there and working on the same thing."

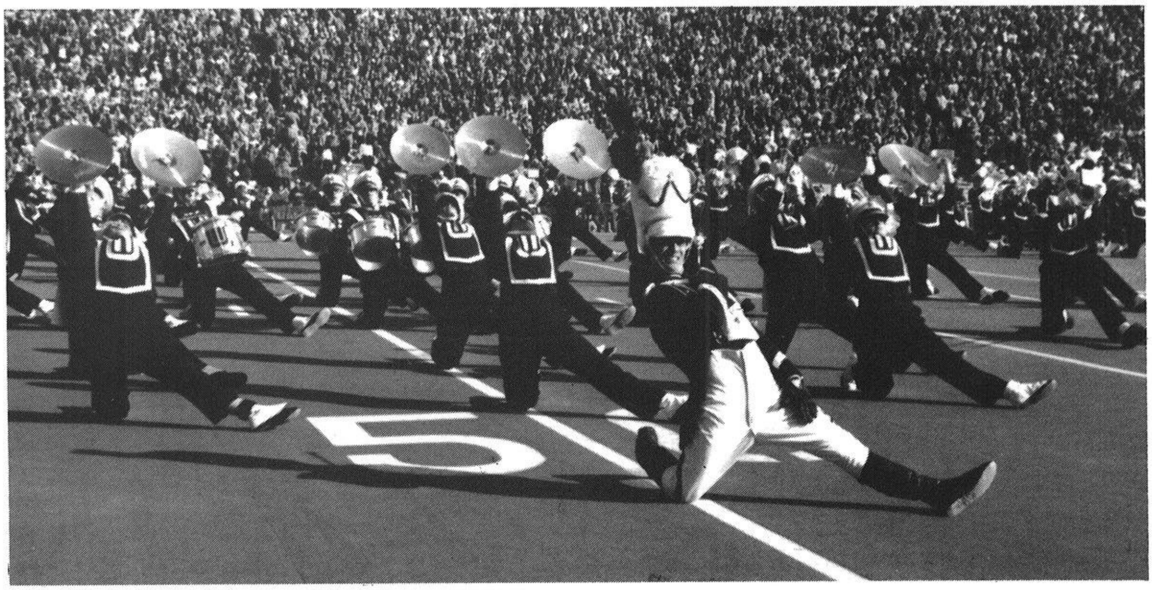
"In engineering, you really have to try keeping an open mind—always looking for something completely different," he says. "As far as my engineering work goes, I don't really do things by the book. I may come up with some idea that's so completely off base and will never work, but invariably I've found that someone else will hear me and say, 'Wait a minute. That's kind of stupid, but that brings up this question.' If people get so ingrained in a set style of thinking, they basically lose their creativity and become a walking textbook."

The band helps engineers gain valuable social skills. "Being in the band, I'm not afraid to get up in front of people and perform and make a fool out of myself," he says. "I've always tried to stick out in the band and be a real character—I like being noticed."

Roy made the band his freshman year and is now percussion section leader. He almost quit after the first day, but he remembered the enthusiasm in the rest of the people and saw how fired up all the veterans were. His favorite part of every show is when the tubas and drums march out for pregame and they're the only ones anyone sees. "The first time I marched a show, I marched through the tunnel and saw 75,000 people," he says. " I made the mistake of looking up and started freaking out. Two years later I got a bigger thrill when we marched in Michigan in front of 105,000 people and received a standing ovation."

His most memorable experience is from the day he returned after spending three weeks in the hospital because of a near-fatal fall (he locked himself out of his house and was climbing up the porch) that almost ended his marching season. Someone sent him up in the stands to check out the lines, and that's when he noticed that they weren't doing pre-game, but were spelling out his name on the football field.

—by Tony Wolfram

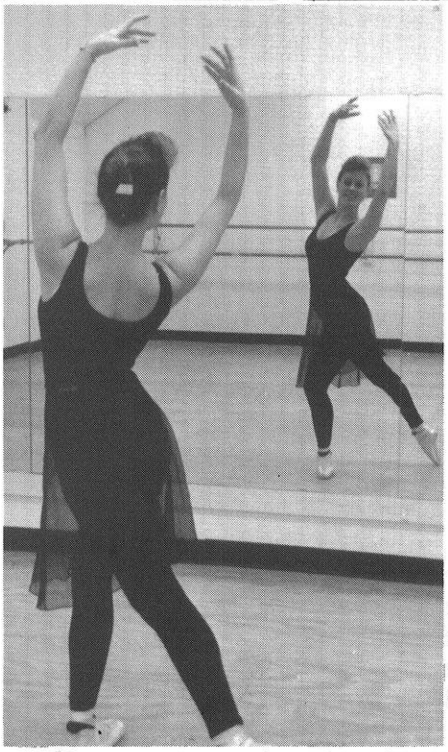


HOPE FASKING EGR/1

Ballerina and Miss Wisconsin hopeful

At age eleven, Hope Fasking performed her first major role in a ballet. The character was Clara, a little girl who dreams of sugar plums and princes in "The Nutcracker Suite." That lead role was Hope's third performance in the Wisconsin Dance Ensemble's production of the ballet, and since then she has appeared in The Nutcracker seven times. "It is all part of studying dance in the Madison area," she explains. "Every year, the area studios form the WDE and concentrate on the production from September until December."

Hope has been studying dance for thirteen years. She began in ballet, tap, and jazz but after nine years she focused her attention on ballet. "Dance has always been a hobby for me. I never really considered dancing professionally, but I don't know when I'll give it up." As well as taking instruction at the Monona Academy of Dance and in a dance class at the UW, Hope teaches ballet to four and five year olds.



Shelly Hoffland

Her experience in dance has already payed off. Last August, Hope was crowned "Miss Sun Prairie", an honor based on poise, personality, and talent. "I entered the pageant on a fluke. But the prize for winning was a scholarship, and I really wanted that. The ballet dance that I used for the talent probably won for me." Now, Hope is entitled to enter the Miss Wisconsin pageant in June, an opportunity she refuses to pass up. "I do not expect to win, of course, but there are a lot of scholarships for nonfinalists who do really well in talent. I do expect to do well. Believe it or not, not many of the contestants can dance ballet. I think that gives me an advantage."

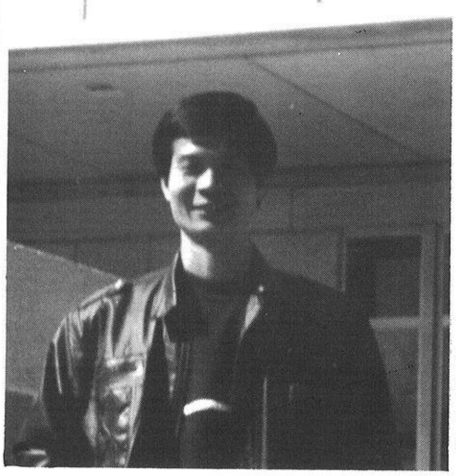
Hope prepares herself for the most important ballet dance of her life by dancing five times a week. However, she does not allow her dancing to infringe on school. As a pre-engineering student, Hope is experiencing her first year of college, though the "campus lifestyle" is not new to her.

"I grew up right near Madison (Sun Prairie) so I was exposed to the college life all the time. Older friends from high school would invite us up to party on campus quite often. So I knew what it was like here.

The adjustment from living at home to living in the dorms with the basic freedom and independence granted to college students has been easy for Hope. Throughout high school, her parents

CHIN-CHAUN YANG EM/GRAD

Taiwanese Grad Student



Shelly Hoffland

Attending the University of Wisconsin-Madison can be a difficult task in itself. However, coming to this university form another country can be very laborious. The language barrier alone can be a great obstacle to overcome. Chin-Chaun Yang has very successfully met this challenge. Yang, a 29 year-old from Taiwan, is a graduate student in the Engineering Mechanics department. He has earned both his B.S. and M.S. degrees in Civil Engineering from the National Cheng Kung University in Taiwan.

Yang is now working on an independent research project. He is attempting to discover the analytical methods that will determine the direction of fibers that will maximize strength, when exposed to in-plane tensile, compressive, and shear loads.

In addition to earning his two engineering degrees, Yang also taught engineering mathematics in Taiwan. After earning his degrees, he served in an artillery unit in the Taiwanese army. Every male citizen in Taiwan is required to serve two years in the army after graduation from either high school or college.

In comparing teaching methods of American and Taiwanese professors, Yang believes that both are very similar. However, he does admit that professors in Taiwan are more thorough. The professors there ask more questions in class, and will repeat the material as often as necessary to insure that all of the students understand the information that is presented. Yang also feels that exams in UW engineering courses are too long for the time allotted.

This is Yang's first year in America. He is tutored by a journalism student to help him improve his English. Sometimes during class the language problem prevents him from understanding some information. Usually though, he can figure out the meanings of words and allowed her to do basically as she pleased. She possessed the responsibility to handle the pressures of college. Hope finds that people are surprised when she says that she is an engineering major.

"I don't know if people think I cannot handle engineering because it is a generally difficult discipline or if it's because I am a woman."

"It is fortunate that engineers earn a lot of money, but I am here because engineering interests me. If art interested me, I'd be an artist, even if it meant making little money. I'm simply doing what I want to do." Hope concentrates on mechanical engineering because she likes math and science but prefers physics and calculus to chemistry and biology. Does studying dance help Hope study engineering?

"Yes! I have a lot of discipline that I credit to dance. I knew that by coming to a Big 10 school and majoring in engineering, I'd have to study constantly. I hate to receive low grades, just like I hate to make a mistake in dance. When I do either I get mad at myself and that pushes me to work harder."

— by Shelly Hoffland

sentences while reviewing his notes later.

As this was Yang's first year in America, it was also his first taste of winter weather. He took the opportunity to try cross-country skiing, and is looking forward to experiencing downhill skiing. Yang also enjoys watching cable television, especially basketball and football. Watching TV helps him brush up on his English, and cable TV is a new experience, since Taiwan has only three channels available.

Chin-Chaun Yang is engaged, and is hoping his fiance will be able to join him in America this summer so they can be married.

His future plans include graduation in May, 1991, and then returning to Taiwan to secure a job in the auto industry.

—by John Stangler and James Giefer

DON DAVEY ME/2

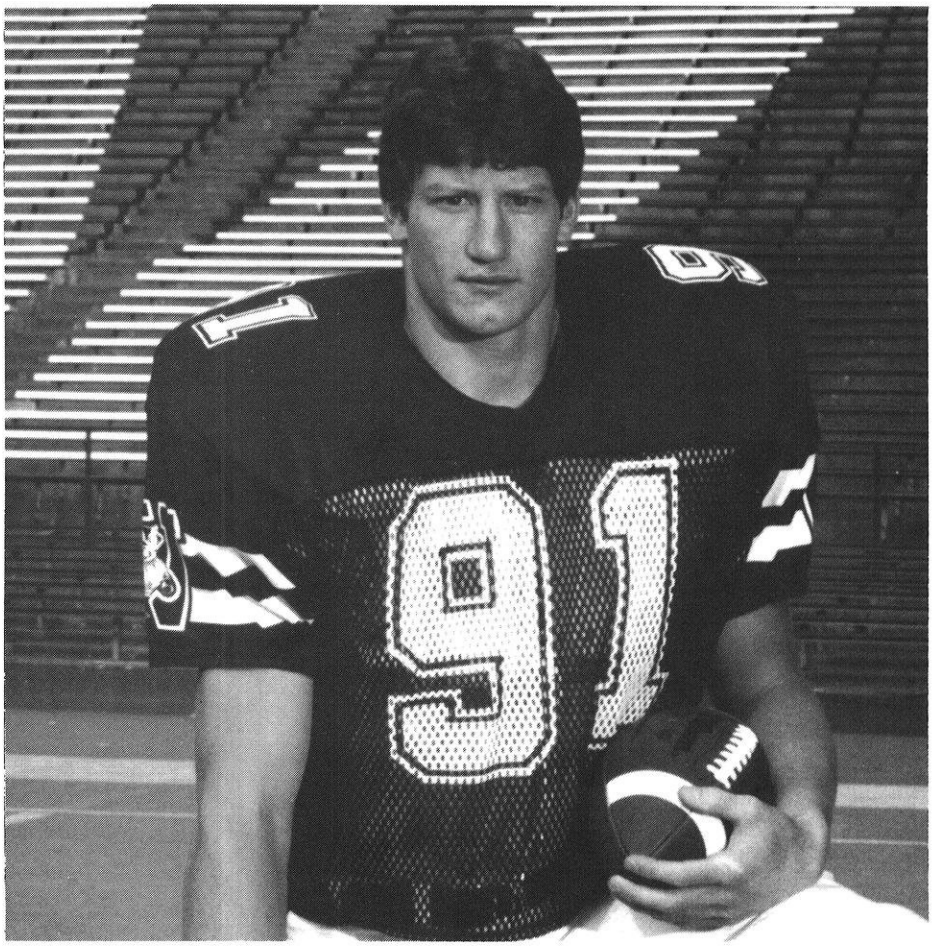
Wisconsin Badger football star and Academic All-American

At six foot-five inches, 237 pounds, Don Davey runs the 40-yard dash in 4.8 seconds and starts on defense for the Wisconsin Badgers football team. Not the type of guy you want to run into on Camp Randall's artificial turf. With a 3.96 GPA in Mechanical Engineering, he's not the type of guy you want to compete with on an exam either. Having been selected as an Academic All-American this year—an honor given to only the top 48 division one starters or key players with high GPA's in the country—he has been interviewed by TV stations, newspapers, and even had a Sports Illustrated writer follow him around for a week (with plans on using the article in the upcoming college and pro preview issue).

After putting 50-60 hours a week into playing football, practicing, lifting, and watching films, he still finds time to meet the grueling and often unrewarding demands of being an engineering student. Even with all his hard work and dedication he doesn't believe student athletes should get paid. "This is college football," he says, "we're not professionals."

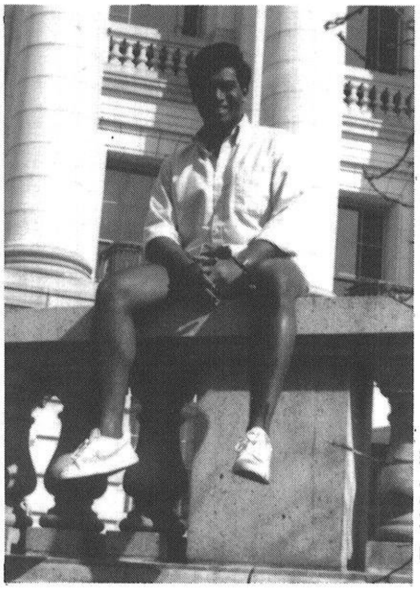
The University of Wisconsin-Madison football program is recognized for the emphasis the coaches put on graduating their football players. Former head coach Dave McClain was proud that 18 out of 20 seniors were going to get their degrees the year they went to the Hall of Fame bowl in 1984. Don stressed that "most of the guys on the team are serious about getting their degree and realize that more than likely they will not end up playing football in the pros." He doesn't plan on playing professional football but if the opportunity came up he says he "would take a serious look at it."

—by Tony Wolfram



MOHAN TATIKONDA EE/GRAD

former WSA Co-President



Todd Schellhase

"It would really help engineering students if they could be given a little bit more time to be involved in student organizations where they're working with other people and developing communication skills," says Mohan Tatikonda, UW-Madison's 1985-86 Wisconsin Student Association Co-President.

According to Tatikonda, there is no shortage of activities or opportunities for leadership on this campus. "If students are interested, they should take a few credits less and spend some time having fun. It will probably make you a better job prospect and you'll be a better person because of it. I traded off my G.P.A. for two years of student government involvement. It was a calculated trade-off, but I'm finding out now that I made the right decision."

Elected by a campus-wide body of 46,000 students, he had a half-million dollar budget and full veto power over $5.5 million in student fees. Averaging 50 hours a week in a job he called exciting but very tiresome, Mohan helped restructure WSA by developing new personnel policies and procedures while increasing communication to student organizations. His engineering skills definitely helped him during his term. "Even though the engineering curriculum is designed to create engineers and not managers, engineering students tend to excel at what they do," he says. "They are surprisingly aware of many of today's issues and have the capability to focus on larger things and use a logical approach."

—by Tony Wolfram

JENNIFER BROWN IE/4

Homecoming queen and Varsity cheerleader

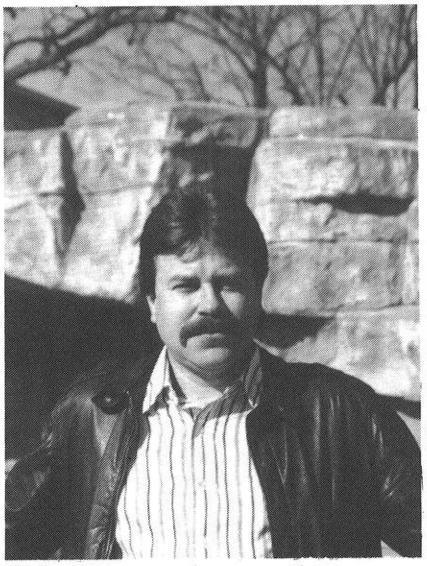
"The more I do, the more I learn about organizing my time efficiently," says Jennifer Brown, a graduating Industrial Engineering student who knows what she's talking about. Having been a varsity football and basketball cheerleader since her freshman year, she has maintained a 3.9 GPA and is currently first in her class of 169. When she's not giving windsurfing lessons or exercising she can be found at the Kappa Kappa Gamma house or The Pub drinking with friends. "I go out all the time," she says, "because if all that I had was school, I would tend to burn out and not work at maximum efficiency. Everyone needs some sort of outlet."

Jennifer was elected the 1986-87 Homecoming Queen representing Tau Beta Pi, an engineering honor society. She emphasizes that being well-rounded and involved in many activities not only improves her well-being but is always discussed during job interviews. She says that the secret of accomplishing so much is intensity. "When I play, I play hard. When I study, I study really hard. Both are at extreme opposite ends and

BILL SCHULTE ME/3

Father and Vietnam Veteran

Ten-year-old Lucas Schulte put his arm around his dad and said, "I'm gonna really get good at math and all my studies in grade school and high school because I don't want to struggle like you do." Having left his job of seven years as assistant plant engineer at Grede Foundries, Inc. in Reedsburg, WI, Bill Schulte fulfilled a lifelong dream by enrolling at the University of Wisconsin. Struggling with the pressures of living away from his family during the week and trying to complete his degree as soon as possible, he must study all the time. "I take my studying very seriously," he says. "I feel that it is my job, it's my career." His wife and son rarely come down to visit and there is no time to spend in the Rathskeller of the Memorial Union socializing with classmates. Visions of walking in the woods with his wife and fishing with his son gnaw on him at 2 a.m. when he's alone in his apartment studying. The 40-year-old student is sacrificing so much now because he hopes to receive enough training and education to qualify for well-deserved promotions.



Shelly Hoffland

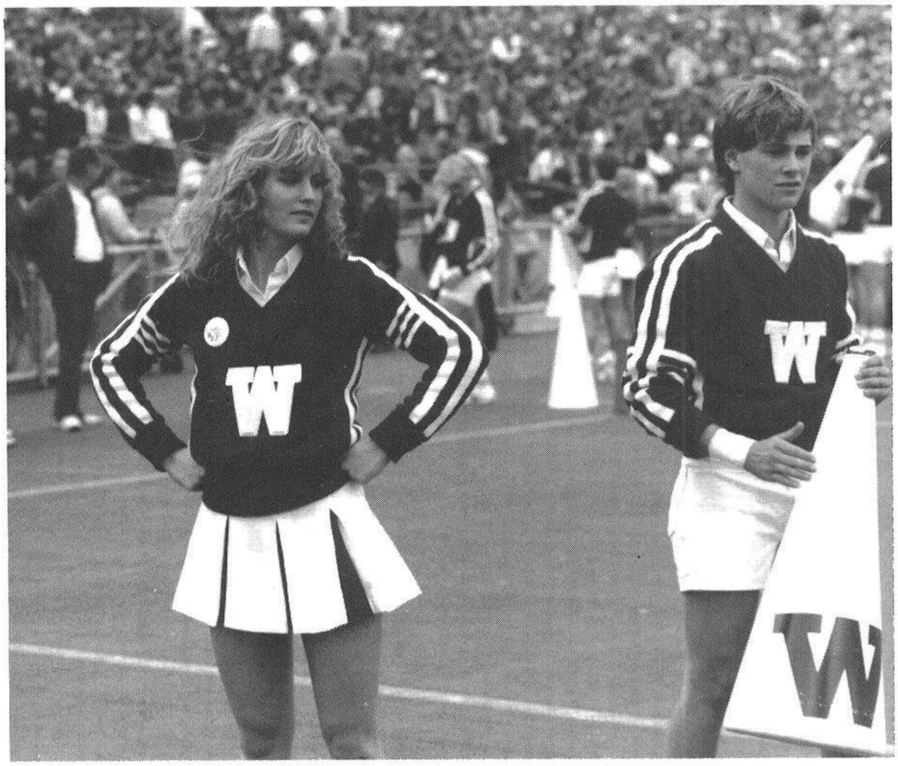
"I was in a stalemate where it was difficult to move," he says. "I found that most of the people being promoted and offered new job positions were graduate engineers."

Bill, who was an infantry "grunt" in Vietnam during 1967 and 1968, had been upset with himself for not pursuing his education when he got out of the service. Confused and not knowing what to do, he went back to his previous employer to work for a couple of years. Even after completing two years of school in civil engineering at MATC, he was still driving forklifts and working in warehouses because it was too difficult to find a good job with his degree.

By the time he understood the necessity of receiving an engineering degree, his funding for college through the G.I. bill—earned through service as a "tunnel rat" in Vietnam—had expired it's ten-year limit and he couldn't afford to attend college.

Bill has always been interested in environmental issues and alternate energies. He feels that our support system is not only the economy, but nature itself. "Today's engineer has to be trained in another way to not only foster the economy but to make sure that he perceives the problems that can affect our environment," he says. "But all too often the engineer coming out of school is pursuing something for his self-gain instead of something for all mankind." He believes that we have to look at environmental studies and ethics more closely. "We have to live and learn that stuff," he says, "it has to start in the classroom. It has to start at home."

—by Tony Wolfram



compliment each other. My breaks and activities take my mind off of studying so I can go back with a fresh attitude and study really hard."

The University's beautiful campus and exciting night life are two things that Jennifer will miss most when she graduates. However, they have never forced her to miss a single class. She is constantly taking notes and absorbing as much as possible because she feels that the 50 minutes spent in the class room should be used as efficiently as possible, saving an hour of studying at night.

Her advice to other engineering students is to "expose yourself to many different types of activities and become active in those you enjoy most. There is so much to experience and do in Madison."

—by Tony Wolfram

MARY ROGINSKI
ChE/3
UW-Women's varsity swimmer

Nawdeep Arora

As former UW-women's Varsity swimmer Mary Roginski finishes another lap and climbs out of the pool, she exclaims, "I love to swim even more now that I don't have to compete in races." She also says, with no regrets, that the decision to quit racing and become a manager has given her more time to enjoy school. Spending all of her time with other swimmers for two years never gave her exposure to other engineering students. Now, she says, "I enjoy my time with the engineering crowd much, much more! I am happy with my decision because I have learned much more and can associate with people that have different backgrounds and ideas."

Having been accepted at Notre Dame, MIT, Berkeley, and Illinois, Wisconsin caught her eye by offering her a two year swimming scholarship and by having what the Decatur, Illinois native describes as "a beautiful campus with a perfect learning environment and a broad spectrum of people."

Mary is an officer in Tau Beta Pi, an engineering honor society, and particularly enjoys the exposure the group gives her to other types of engineering students. "I'm usually in class with all Chem E's and that's all I ever see, " she says, "and in TBP I get to meet ME's and IE's and EE's and they're all different. I even found out that ME has this friendly clan of students because of their study area in the ME building. "

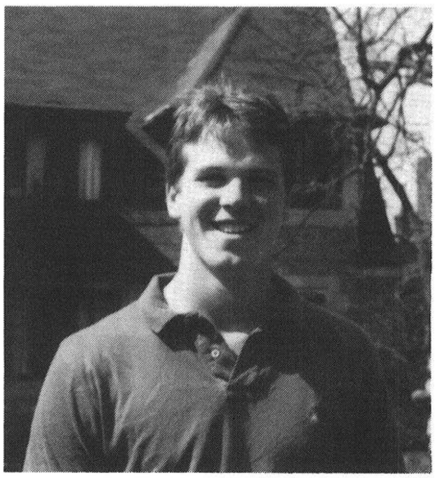
Being a woman in a male-dominated field hasn't posed any problems for Mary. In fact, she has become friends with more male engineering students in her classes than with women. She wants to dispel the myth that the female engineers ban together. "I personally feel more in competion with the other women than with the men," she says, "because I feel that women engineers are such an elite group, and if I'm already that high up, why not be the best?"

Mary doesn't think that there is any typical personality that makes up a Wisconsin engineering student because there are so many different kinds of people in Madison—from the way left to the way right to the way out!! "I look around and see a class of engineers studying so seriously and think, 'Geez, these people really are geeks.' But then I get to know them, and there are so many different and fascinating types of people, that it's incredible," she says. "I wouldn't even begin to try and stereotype them. There are some annoying people, granted, but not any more

GLENN THOMAS IE/4
FIJI Fraternity President

Only two weeks after becoming chapter president of Phi Gamma Delta(FIJI) fraternity, Industrial Engineering student Glenn Thomas was thrown into the spotlight of Wisconsin and the nation. Students protested a Fiji Island party where fraternity members wore black makeup and tropical garb and erected a giant caricature of a black island native with a bone through his nose. The spring party cost the fraternity fall rush privileges. Then, approximately 300 Madison students protested again when the fraternity was reinstated even after several members got into a fight inside a predominantly Jewish fraternity. Glenn was quoted in Newsweek warning members that "now is not a good time to get in any kind of trouble—racist or not."

The responsibility of being spokesman for the Fiji's and responding to the sharp criticism of his members was thrust upon his shoulders. "I kind of had to do it alone because I was the spokesman for the house," he said. "But I could get a lot of advice from a lot of people. We had some prominent alumni in public relations fields that came in to help me out. It was harsh, though. I never had anything to do with the press before and here I am on television and written in every newspaper with my picture in the paper and people confused the whole subject."


Todd Schellhase

He disagrees with the protesters accusations of racism within the fraternity. "People were calling us racists and they didn't really realize that none of it was true. I have a black pledge brother. It was a real hard situation for all of us.

"I was spending the whole first semester this year dealing with the faculty and staff and alumni trying to get our student status back and it was really hard to do school work and keep up as an engineer while doing that," he said.

"I dropped down to 9 credits and spent all my time in the press and then finally there was that fighting incident and that threw us right back into the spotlight. Since that incident I've been on the McNeil/Lehrer News Hour and International Satellite Television."

All the publicity and criticism started to affect the fraternity, but Glenn thought there was too much. "They really never asked me about anything but like 'why did you do this and do you think it was racial?' It was all racism, racism, racism. They never talked about what the fraternity is all about—it was really harsh," he said. "The hardest part annoying than in any other profession."

She believes that engineers are highly respected by most people."Engineers are almost mythical in our society," she says. "People find out that I'm an engineer and are awed by it. The next question is always 'What do you do?' because they have no clue what we really do." She also says that people are surprised to learn that engineers are real people too.

One of the reasons she gives that students are unfamiliar with engineers at UW-Madison is that they spend so much of their time on the engineering campus. "It has been months since I've seen Bascom Hill," she says. "The engineers are stuck way over in that corner by Camp Randall and that's where all of our classes are and where we spend all of our time. The majority of people at Union South and Kurt F. Wendt library are engineers because that's where we live."

—by Tony Wolfram

about it is that this is a very liberal campus and Greeks aren't really loved here anyway necessarily. They were taking it out on the whole Greek system and they weren't very willing to listen to the fact that the fraternity could be a good thing. They just wanted to see why we would do something bad. It's almost like they expected us to do it. It wasn't because of the fraternity that the incident happened. We were proven innocent of that-it was just a couple of guys."

Besides making the public more sensitive to racism on campus, Glenn sites personal growth as a result of the incidents. "It was good for me, actually, because it taught me a hell of a lot about the way some things work and it gave me a lot of confidence in being able to speak in front of others," he said. "I gave press conferences and I had to give speeches at our meeting of all the FIJI chapters from around the nation over the summer. So I got a lot of public speaking experience. Those were new experiences for myself, as well as for a lot of other guys in the fraternity."

—by Tony Wolfram

STEFANIE SMITH
ChE/3
WBESS co-president

At the age of 16, Stefanie Smith left Washington, North Carolina to attend the University of Wisconsin. With her two best friends deciding not to come with her at the last moment, she found herself alone in a three bedroom apartment and lost on campus. She definitely needed a support group, and found one with the Wisconsin Black Engineering Student Society. The student members helped her with studying and getting a summer job, and today some of her best friends are in WBESS.

Now she is co-president and helps freshman through registration and seniors to find co-op jobs. Stefanie says that the three main objectives of WBESS are to enroll students into the program, help them through difficult times while in school, and successfully graduate them into productive jobs. "Minority students not involved would probably do better if they were with WBESS," she says, "because Wisconsin is a very difficult school to graduate from."

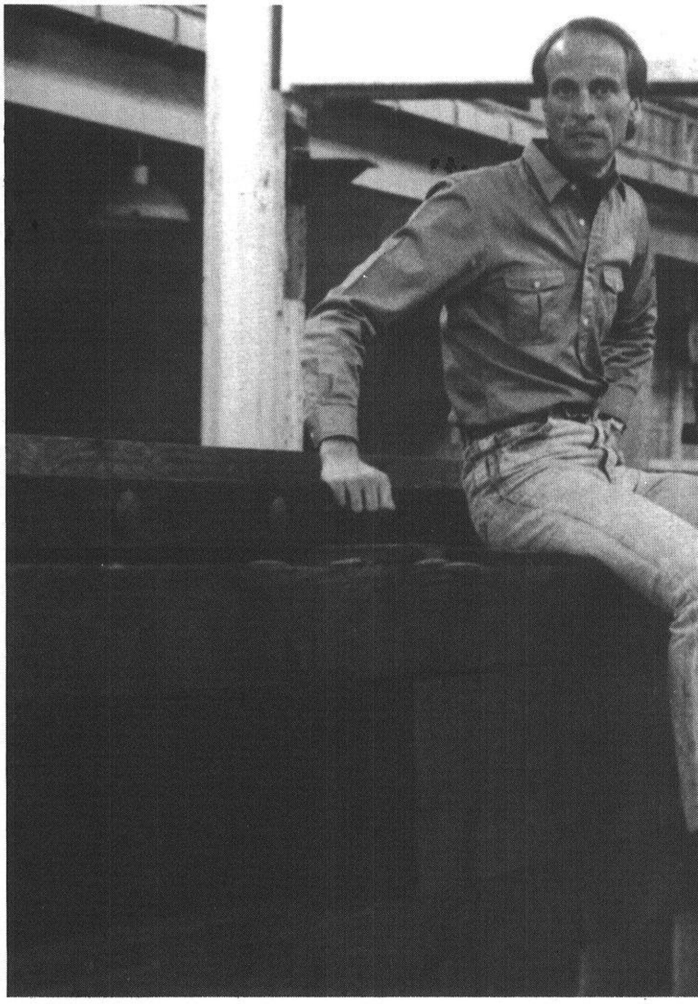
"The issue of racism on campus is not made up," she says. "There have been times when my friends and I have been called racist names, but personally, I've not had a problem on the engineering campus." Even though the University may not heavily recruit minorities, Wisconsin's great engineering program appeals to many minority high school graduates. "You really can't escape racism," she says, "and I don't think you can run away from something that is so ingrained in our society."

A company that she worked with during the summer was concerned that there weren't enough blacks or minorities in the board of directors or in managerial positions. They admitted that the older white males in upper level positions weren't promoting minorities, and are now making a conscious effort to promote qualified minorities from within. Some opponents of affirmative action argue that companies are giving jobs to people that are not qualified. "If you can't do the job, you're not going to get hired," she says. "If I've found anything, it's that you have to be overqualified in order to get the same treatment and recognition."☐

— by Tony Wolfram


Todd Schellhase

Faculty Profile:
Michael Oliva



Michael Oliva

by Brenda Lehman

"I never intended to go into engineering," Michael Oliva, assistant professor of Civil Engineering, said in a recent interview. Actually, he wanted to be an architect, but Wisconsin didn't have the schools and he couldn't afford out-of-state tuition. He decided to try engineering because, as he said, "Frank Lloyd Wright didn't start out in architecture, either."

After receiving his undergraduate degree in Wisconsin, he went to the University of California, Berkeley, where he worked on several research projects all dealing with concrete. In 1979 he received his PhD and headed back to his native state of Wisconsin. Professor Oliva believes that "Madison is a nice place to be."

Although Wisconsin doesn't border the Pacific Ocean as California does, Professor Oliva takes full advantage of the many lakes and rivers that Wisconsin does have. He enjoys canoeing and fishing whenever he has the time. "It's a way to clear all the cobwebs out of your system," he said.

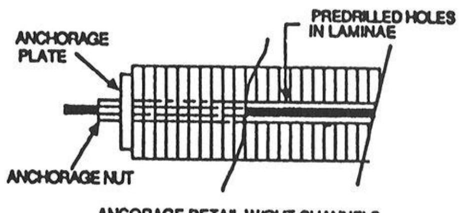
Professor Oliva likes to be outdoors in the winter also. If you happen to be by the railroad tracks located near the engineering campus at the right time of day, you might see him travelling to or from work on cross country skis. He believes skiing is a great way to start and end a day, freeing him from the tensions of work.

During working hours, Professor Oliva spends approximately 40% of his time teaching graduate-level courses in concrete design. This semester he is teaching a class in Dynamics of Structures.

During the other 60%, Professor Oliva is involved in a variety of research projects. His research interests lie in structural research, design, testing, dynamics, and analytic modeling. He said that his goal is to develop new methods of design and construction using computer simulation.

One of the most interesting projects he and two graduate students are currently working on is the construction of wooden bridges that utilize today's new technology.

The normal bridge building proce-



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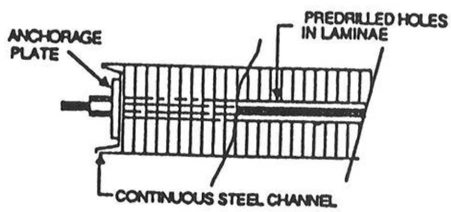

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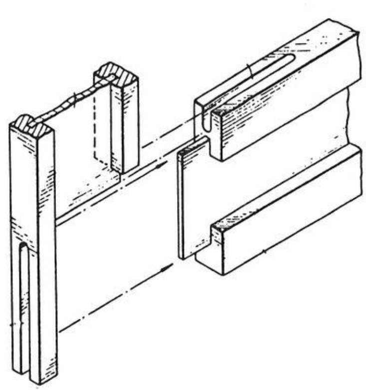
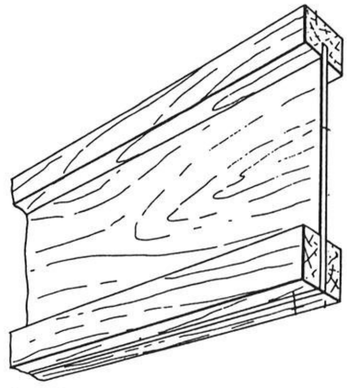
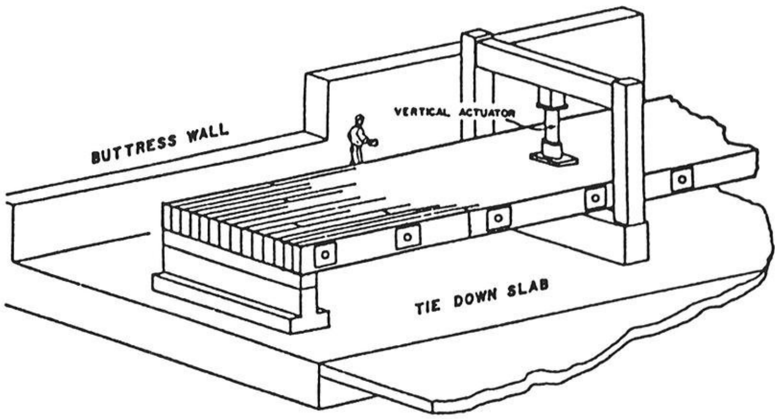
Jeff Roorke



Joint construction



Wooden I-beam



Testing bridge construction

dure is to take wooden timbers, place them side by side, and laminate them together with glue bond, creating the floor of a bridge.

The stickler of cost becomes a problem. "It's a very expensive process; you would actually need the facilities of a factory to do the glueing," Professor Oliva said.

Putting their engineering ingenuity to the fore, Oliva and his graduate students came up with a solution. Laying the beams side by side, they

The only extra machinery needed is a machine to drill the holes. "You could almost do it in your backyard."

drilled holes through the beams, then put steel rods into the holes and exerted a prestressed pressure on the rods; no extra spikes were needed. The result was a sturdy floor that is very inexpensive. The only extra machinery needed is a machine to drill the holes. "You could almost do it in your backyard," Professor Oliva said.

Last March Professor Oliva proved that it could be done at the Pheasant Branch Creek Conservatory in Middleton. After extensive experimentation in the laboratory, Oliva put a timber bridge to the test in the real world. With the assistance of 14 American

This technique is now being used to construct floors in some houses, but Professor Oliva proposes to try this for the floors, ceiling and walls of a building.

Society of Civil Engineers student members, Professor Oliva and his graduate students reconstructed the bridge after clearing and surveying the site. The oak cribbing was put into place, and 4 inch x 16 inch x 8,12,16, and 20 foot members were placed together to allow a 5 inch camber before stressing. The prestressed rods were placed four feet on center and a 70,000 lb. force was placed on them using a small hydraulic jack.

Approximately four or five highway bridges across the United States have been built using similar techniques.

Moving from building bridges to building houses, Oliva is working to develop a new integrated technique for framing wood houses using "I" beams.

"I" beams are constructed with 2 x 4's glued to plywood webs and bolted to wooden joints on either end of the beam. This technique is now being used to construct floors in some houses, but Professor Oliva proposes to try this for the floors, ceiling and walls of a building.

He said that the cavities of the walls will be filled with up to six inches of insulation. He feels that the structure will be much more energy efficient and stronger and expects that it will be able to withstand tornadoes and earthquakes much better than the typical house constructed of 2 x 4's. This new technique may be especially important in apartment building construction.

A courageous graduate student will test the strength of the joint structure this summer.☐

County implements gas recovery system at Verona Landfill

by Brad Melvin

Garbage! What comes to mind? Throwing trash to the curbside for pickup? Burning garbage in the backyard? Probably not dangerous explosions near a landfill. Well, that was the case with the Verona Landfill in late summer of 1986—as a result of burying or landfilling garbage, explosive gases formed as the garbage decayed. The Verona landfill experienced gas migration, or movement of gas out of the landfill, causing explosions in an adjacent private pit well. After installation of a gas migration control system at the northern perimeter of the the landfill, the gas was collected and vented to the atmosphere. Dane County, not satisfied with just solving their immediate problems, has made plans to redesign their existing system in order to collect greater amounts of gas. By expanding the

Explosive gases formed as the garbage decayed.

system, Dane County is expecting to eliminate any future gas migration problems and at the same time generate revenue by using the gas for power generation.

Anaerobic decomposition, the breakdown of garbage in the absence of air, occurs within a landfill. As a result of decomposition, a mixture of approximately 50 percent methane gas and 50 percent carbon dioxide gas is formed. At this concentration, the gas within the landfill is noncombustible. However,

Dane County is expecting to eliminate any future gas migration problems and at the same time generate revenue by using the gas for power generation.

methane does become combustible in concentrations of 5 to 15 percent by volume in air. Landfill gas, if uncontrolled, will either vent upward into the atmosphere or move out of the landfill sides or base. Venting can be controlled by the placement of an impervious soil clay cover over the garbage, but migration of gas may occur. As gas migrates out of a landfill it mixes with air and results in a possibly combustible mixture. The methane-air mixture is very similar to natural gas. It is colorless, explosive, and similar in odor. The Verona Landfill opened in 1977 and, prior to closing during the summer of 1986, accepted 2.1 million cubic yards of waste. The 50-acre facility, located southwest of Madison, contains land disposed garbage (food wastes), demolition debris, and some shredded waste. During the summer of 1986 the landfill was closed and covered with an impervious clay soil layer. The clay cover not only improves the general appearance of the site, but also provides containment of landfill gas and landfill liquids (leachate).

The Verona Landfill experienced gas migration problems. In August, 1986, methane migrated north from the landfill site to a private well pit. The methane accumulated in the well pit and reached concentrations in the 5 to 15 percent range. Several small explosions occurred as the well pump controls switched on and off—Dane County officials immediately evacuated the adja-

The methane-air mixture is very similar to natural gas. It is colorless, explosive, and it is similar in odor.

cent private residence. They also implemented an emergency response gas migration control system; eleven gas extraction wells were installed at the

Jeff Roorke

The Verona landfill

northern perimeter of the site. The gas extraction wells are connected by common poly-vinyl chloride (PVC) piping to a negative pressure blower. Gas is pumped by the negative pressure blower to a common point, where it is then vented into the atmosphere. Gas monitoring alarms were also installed around the landfill to indicate how the system was performing. If gas concentrations rise above 0.5, percent the alarms are triggered. According to Ken Koscik, Dane County Director of Public Works, the gas extraction system has reduced methane concentrations around the landfill. "The monitoring alarms have been in existence two years and have never been triggered due to concentrations higher than 0.5 percent," he said.

Upon controlling the emergency gas migration problem, Dane County set its sites (sic) on designing and implementing a gas recovery system within the landfill. They are proposing to replace the perimeter gas extraction system with a gas extraction system within the landfill. More gas with a higher BTU heating value can be extracted from within the landfill interior. Not only is Dane County hoping to eliminate any future gas migration, they are also hoping to generate revenue from the production and use of landfill gas. Recently, Dane County has received Wisconsin Department of Natural Resources (WDNR) approval of their proposed gas recovery system design. Warzyn Engineering, a Madison consulting firm, designed the proposed gas extraction system for Dane County.

Dane County, by immediately responding to the northern migration of gas, averted a possibly dangerous accident.

The County proposes to extract landfill gas for energy recovery to use as a supplemental fuel for the boiler units at the nearby Dane County Badger Praire Health Care Center or as a source of on-site power generation. The proposed system consists of 20 gas extraction wells located within the landfill that will extend to within three feet of the landfill bottom and will range in depth from 20 feet near the outside of the landfill to 45 feet in the interior of the site. The wells will be connected by approximately 6000 lineal feet of a high strength, flexible, high density polyethylene (HDPE) header pipe allowing for settlement within the landfill that may occur in the future. The gas, under vacuum, will be transported to a blower housewhere there is safety equipment to insure explosion free operation of the system. Also at the blower house, the gas will be conditioned to remove excess water vapor. Conditioning will improve the combustibility of the landfill gas. Depending upon the results of an economic analysis, the landfill gas will either be used as a supplemental fuel for the boiler units at the Dane County Home-East or as a source of on-site commercial power generation. In the event both alternatives are not viable, the gas can be combusted at a flare near the blower house. However, Dane County is expecting the Health Center to be their best option to generate revenue. The existing gas migration system will remain intact to be used as a backup if the proposed system fails to perform.

Dane County, in 1986, averted a possibly dangerous accident by immediately responding to the northern migration of gas. However, the County is not satisfied with just the implementation of the emergency gas migration control system. They have looked for ways to eliminate future gas migration problems and are also hoping to, at the same time, generate revenue from the collection of landfill gas. It appears Dane County is headed toward that goal with the approval of their proposed landfill gas extraction system.□

Engineering Briefs

by John Collins

Boisjoly to speak at UW

Roger Boisjoly, a former engineer for Morton Thiokol, Inc., will be on campus the evening of May 2 to discuss the events leading up to the launch of the space shuttle, Challenger, in his speech "Ethical Decisions". Mr. Boisjoly's speech promises to give important insight to his struggle with management to halt the disaterous launch as well as his views on ethics in engineering. He is scheduled to speak at 7:30 p.m., May 2, in room 159 of the Mechanical Engineering Building. A reception will follow at Union South.

Fall Co-op Schedule

Students wishing to co-op spring semester of 1989 should keep these important dates in mind.

•Co-op Registration starts during reggie week (Aug. 29 - Sept. 16, 1988), 407 Wendt Library.
•Co-op Office mails out CIFs to employers Sept. 19-30, 1988.
•First interviews are scheduled for Oct. 10, 1988.
•Requirements:
—must be admitted to major department by Sept. 16, 1988.
—must have sophomore, junior, or senior standing.
—must be willing to work starting Jan. 1989.
—must commit to two, three or four work terms (some could be summer).
—must not be on probation.

EARN WHILE YOU LEARN!

College gets $2 million for building project

The UW-Madison College of Engineering has received a gift of $2 million from the Grainger Foundation, Inc. of Skokie, Ill. David W. Grainger, president of the foundation, is a 1950 electrical engineering graduate of UW-Madison.

The contribution is one of the initial gifts to The Campaign for Wisconsin, the major fund-raising campaign now being conducted by the UW Foundation. The gift fulfills a requirement for the private funding portion of a $16.5 million addition to the Engineering Building. The Wisconsin budget bill last July committed $14.5 million in state funding to the project on the condition that the College raise $2 million in private funds. Construction could begin in 1989.

Wisconsin Engineer

Geological Engineering

A new degree program in Geological Engineering was introduced last fall to replace the phased out mining engineering program. Geological Engineering is a relatively new field of study, in fact, Madison is one of only fourteen colleges around the nation which has the program. The curriculum, set up by Professor Bezalel Haimson in conjunction with colleagues from geology and three engineering departments is interdisciplinary in nature. Students will be required to take courses in geology, geophysics and metallurgical and mineral engineering.

According to Professor Haimson, geological engineering is a field on the rise which will undoubtedly require trained individuals to face problems in the areas of design and analysis of underground structures, reduction of natural hazards like earthquakes and floods and new methods of mineral extraction, energy storage and waste disposal.

Pre-Engineering Student Society

A new student organization aimed at introducing pre-engineering students to the college in their freshman and sophomore years has recently been formed. It is called the Pre-Engineering Student Society (P.R.E.S.S.). According to Scott Braun, a member of P.R.E.S.S., the society hopes to make the engineering campus more accessable to beginning students by providing contact with engineering societies and fraternities and supplying information about scholarships and activities on the engineering campus.

On April fifteenth, P.R.E.S.S. hosted a "day on campus" for more than one hundred high school seniors accepted to the school. Each prospective student spent the day with a pre-engineering student who introduced them to all aspects of the school including classes and the dorms.

PRESS welcomes any prospective engineering student to join. If you are interested, call president, Steve Rieder at 264-2196.

TRACE Center

Professor Gregg Vanderheiden of industrial engineering is director of the UW-Madison TRACE center for rehabilitation engineering. The center focuses on new and improved methods of communication, control, and computer access for the handicapped.

Vanderheiden and his colleagues have developed a system which allows a severely handicapped person 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.

Vanderheiden has also invented a long range optical pointer that allows users to type by pointing a light strapped to their head at a keyboard displayed on a computer screen.

Some of these developments can be adapted to improve computer design for the general population as well. "For example, if you make something so people with poor vision can see it, people with good eyesight experience less eyestrain when they use it," Vanderheiden says.

Auto Emission Controls:
History and Hardware

by Paul J. Gassere

Smog. It even sounds ugly. The word was coined in England over 100 years ago to describe the noxious haze that blanketed cities, blackened buildings and tarnished silver in places where coal was burned. Smog means smoke + fog. The true cause of smog lies in the incomplete combustion of hydrocarbon fuels such as coal and gasoline in air and the oxidation of sulfur compounds.

Smog formation involves photochemical reactions between hydrocarbons, combustion products and oxides of nitrogen and sulfur in the presence of sunlight. It is no surprise that modern smog first reached alarming levels in Los Angeles in the 1950's. Combine lots of cars and plenty of sunshine and the result is an eye-irritating, lung-stinging pall of airborne filth. Similar problems have appeared in other American cities and in Japan for the same reasons. Western Europe is just now experiencing smog bad enough to bring about auto emission regulations and a phaseout of leaded gasolines.

The components of auto exhaust that have been identified as smog-causers are hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and oxides of sulfur (SOx). In urban areas an estimated 60 percent of such pollution comes from motor vehicles with the rest coming from power plants and industrial smokestacks.

California enacted legislation for the progressive reduction of air pollution from automobiles starting in 1964. The clean Air Act and the formation of the Environmental Protection Agency (EPA) were brought about in the 1970's amidst the environmental movement of the times. As a result of a national outcry against pollution in general and air pollution specifically, an agenda was set calling for a 90 percent reduction in auto emissions and a total ban on leaded gas by 1980. Give or take a few years, these goals have essentially been met. As of 1988, the amount of lead emitted from gasoline engines has been cut by over 90 percent and emissions of HC, CO, NOx and SOx have been reduced by 75 to 90 percent depending on the data being examined. True comparisons are difficult between 1968 and 1988 due to advances in test equipment and data interpretation methods.

WHERE AUTO EMISSIONS COME FROM

In an uncontrolled automobile engine, air pollutants come from three places; the tailpipe, gas tank and crankcase. The proportion of pollutants from these sources is roughly 5 percent evaporation of raw fuel, 20 percent from the crankcase and the remaining 75 percent from the exhaust.

Evaporation losses from a vented gas tank and carburetor bowl in a 1957 Chevy could be greater than a gallon per day in hot weather, even if the car isn't driven. Crankcase vapors were not identified as a significant source of air pollution until about 1959. Before that, crankcase fumes were considered a minor nuisance odor and simply vented to the atmosphere through a pipe aimed at the road, aptly called a road-draft tube. Studies at the General Motors research center in the late '50s analyzed crankcase gas and found it to be small in volume but very rich in pollutants, especially raw hydrocarbons. Blowby, or the leakage of compressed mixture or combustion gases past the piston rings, is unavoidable in IC engines and gets worse as engines grow older.

Exhaust from an uncontrolled engine contains unburned hydrocarbons, carbon monoxide and oxides of nitrogen for many reasons. Oxides of nitrogen result from high combustion temperatures and pressures. Nitrogen, making up about 79 percent of air, "burns" to some degree in an engine, yielding NOx compounds. Other undesired combustion products like CO and HC result from the complexity of the gasoline/air combustion reaction(s) and the physical realities of production engine construction.

Pre-control era cars (@1966) were virtually designed to pollute. The crude carburetion systems, troublesome point type ignition and combustion chambers designed with no thought concerning emissions all contributed to the problem.

LEADED GASOLINE

In the 1930's engines had compression ratios of 4.5:1 and ran on 60 octane gas, both pathetic by modern standards. Tetraethyl Lead (TEL) was invented in 1922 but was not in common use until the 1940's. A highly concentrated and inexpensive anti-knock agent, TEL or Ethyl came into the spotlight during WW II. The air war required 100+ octane gasoline for combat and transport aircraft powered by supercharged air-cooled radial engines. The availability of refinery capacity to produce this kind of fuel was available after the War and Detroit jumped on the 100+ octane bandwagon by jacking compression ratios up as high as 12:1 on production cars. A 1947 report by the Standard Oil Development Company predicted that higher compression ratios and the universal use of leaded premium gas would increase the gas mileage or power of the average car by 50 percent compared to pre-war models.

The fact that TEL is a deadly poison has been known since 1923 when several workers at the plant where TEL was made died of lead poisoning from absorption of TEL through their skin. The economics of leaded fuel were excellent; a few grams of TEL per gallon made for great gasoline. The amount of lead put into the air was considered insignificant or played down by Detroit and the oil companies.

People no longer wanted to breathe airborne lead from gasoline.

TEL was also found to have favorable lubricating properties for exhaust valves. Less expensive materials could be used for valves and seats, so auto makers designed engines around leaded fuel from 1948 to 1970.

The environmental movement of the late 60's created public outcry over heavy metals and their compounds. Mercury and lead were targeted for their toxic effects, entry into the food chain and persistence in the ecosystem. People no longer wanted to breathe airborne lead from gasoline. Auto makers and oil companies resisted an immediate lead ban on the grounds that every engine built since 1942 would have to be scrapped or rebuilt due to valve damage. Legislation was put into effect for a gradual phaseout of leaded gasoline starting in 1971 and ended with a complete ban by 1980.

As of 1971, all engines made or sold in the U.S. were equipped with suitable valve and seat materials and lower compression ratios so that they could burn lead-free gas. Few motorists bought lead-free gas because the mainstay of the oil industry was still leaded regular and lead-free was both more expensive and harder to find. The long-term significance of this is that any car built after 1970 should be able to run on unleaded gasoline without valve damage.

A virtual death certificate for leaded gas in the U.S. was issued in 1975. Catalytic converters, "UNLEADED FUEL ONLY" stickers, and small gas tank filler snouts had arrived. In addition to making most new cars unable to burn leaded fuel, the EPA also mandated a gradual reduction of the lead content of leaded gas. In 1973 leaded regular gasoline contained an average lead content of 0.13 gram/liter. In 1988 the so-called leaded regular for sale contains only about 0.03 gram/liter. This approaches what is legally considered unleaded gas in most other countries.

The fact that TEL is a deadly poison has been known since 1923 when several workers at the plant where TEL was made died of leading poisoning.

Between fleet turnover and lead content restrictions, the amount of lead entering the air in the U.S. has been reduced 90 percent or so from 1970 levels.

EMISSION CONTROL HARDWARE

Between 1964 and 1980 the vocabulary of auto parts terms grew by leaps and bounds in order to describe the collection of emission related devices installed on new cars. All of them help reduce pollution, but some of them degrade performance and fuel economy in the process. All of them make cars harder to work on.

Evaporative Controls

To minimize evaporation of raw gasoline from the gas tank and carburetor bowl, all cars built since 1968 in California and 1970 nationwide are equipped with sealed tank vent systems. A typical system consists of a non-vented gas filler cap, a charcoal canister and about 35 feet of tubes and hoses. Fresh air is supplied to the fuel tank through a one-way valve. Fume-laden air is drawn out of the tank and held in a canister containing activated charcoal with several acres of surface area. Fuel vapor adsorbs on the charcoal when the car is not running.

When the engine is running, manifold vacuum draws fuel vapor out of the charcoal canister and continuously purges the fuel tank. Some evaporation still takes place from carburetors , but most of the vapors leaving the float bowl remain within the air cleaner and are drawn in with the air when the engine is started.

First used on military vehicles in World War II to keep out dirt, closed crankcase vent systems are now universal.

Positive Crankcase Ventilation (PCV)

Before 1964 crankcase vapors were ducted out through a road draft tube. Fresh air was supposedly drawn through a filter screen in the oil filler cap and sucked through the crankcase by air passing over the end of the road draft tube. This worked poorly in city traffic and allowed dirt and deceased insects to enter the engine.

First used on military vehicles in WW II to keep out dirt, closed crankcase vent systems are now universal. Fresh air enters the crankcase through a breather hole in a rocker cover. Blowby gases and water vapor are drawn out of the crankcase through the PCV valve and into the intake manifold. The idea is that volatile unburned hydrocarbons and other pollutants are burned in the engine along with the normal mixture. PCV valves are regulated by engine vacuum so as to not upset the basic mixture balance. High vacuum closes the valve down to a small calibrated flow during idle and cruise operation. Full throttle acceleration drops the vacuum and allows the PCV valve to open fully during passing or kamikaze maneuvers on the freeway when blowby is at a maximum.

Deceleration Valves

When the throttle is snapped shut on a carbureted engine, high manifold vacuum draws mixture through the carburetor, even though the engine doesn't need it. High HC emissions result during such transients. Deceleration valves inject fresh air into the manifold to instantly lean the mixture during deceleration. A simple diaphragm and spring device, a decel valve senses higher than normal vacuum and admits air until the vacuum returns to normal. These devices were retrofit to many pre-1966 cars in California to reduce HC emissions.

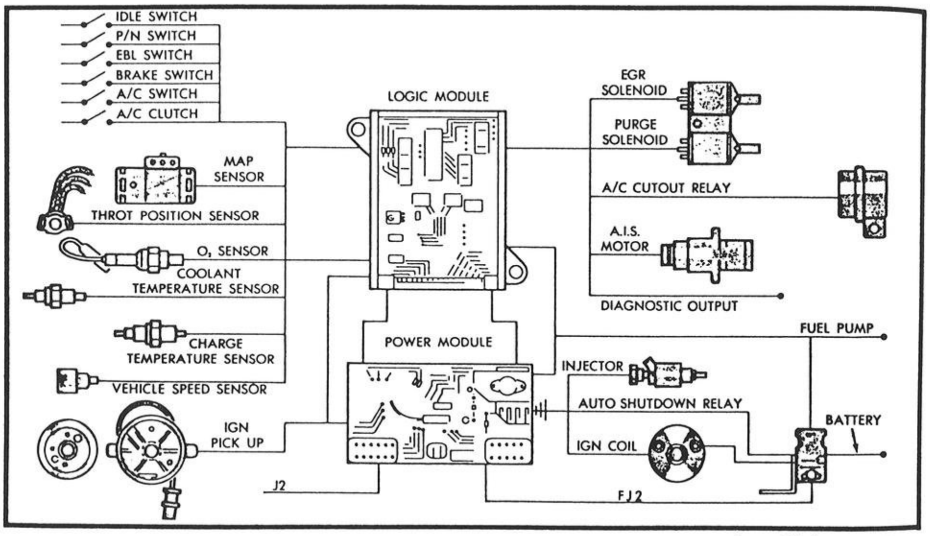
Air Injection (AIR) System

First used on 1966 California models, air injection is still in use on many cars. Unburned HC and CO in the exhaust can be oxidized by the introduction of air to the exhaust just as it leaves the cumbustion chamber. A belt driven pump supplies air through a series of check valves, hoses, tubes and fittings leading to nozzles built into the heads or exhaust manifolds. On catalyst cars, air is supplied by the same pump to the converter itself or a fitting between the converter and oxygen sensor.

Disadvantages of air injection as used from 1966 to 1974 include poor gas mileage and backfire. To reduce NOx and assure the presence of enough unburned HC and CO to support continuous afterburn, mixtures were run rich and spark timing was retarded. The fuel economy penalty was very real, especially during the 1973 oil embargo. A 1972 Chevrolet Impala with a 350 V-8 got 22 miles per gallon on the highway. The same car in 1973 emissions trim got 18 MPG. These are real numbers, not EPA guestimates.

Exhaust Gas Recirculation (EGR)

The idea of feeding an engine some of its own exhaust fumes may sound strange, but it helps reduce NOx emissions by lowering peak combustion temperatures. Small amounts of essentially inert exhaust gas mixed with the incoming mixture also reduces knock tendency and octane requirement. EGR is accomplished by a vacuum controlled valve feeding a passage in the intake manifold or a plate under the carburetor. Some engines have cam timing that retains exhaust by early closure of the exhaust valves. EGR decreases power output and is often deactivated under acceleration conditions.



Schematic of Chrysler EFI system from Chilton, p. 274

Catalytic Converters

The catalytic converter first appeared in production vehicles about 1975 and is used on virtually every car built today. Unlike the fuel-thirsty methods of air injection and thermal reactors, catalyst equipped engines are not de-tuned as badly in terms of spark timing, valve timing or mixture. Catalysts require a lean, clean burning engine in order to function properly. When converters replaced the AIR system of 1974, fuel economy went back up almost to 1972 levels but with much lower emission levels.

Catalysts were first proposed in the 1950's. Various metallic materials were tried, including vanadium compounds, but the materials used today are based on palladium and platinum. The quantity of catalyst metal in a converter is quite small. Surface reactions to oxidize CO and HC are accomplished without consuming the expensive metals. Converter beds are composed of either pellets or a monolithic ceramic honeycomb, usually made of alumina, coated with a thin film of catalyst metal. Current converters use alumina pellets with a 0.05mm thick coating of palladium. The surface area of the pellets in a converter for a 260 cubic inch engine is equivalent to 59 football fields.

Oxygen Sensors and Computerized Fuel Controls

The present state-of-the-art in gasoline engine emission control is based on the microprocessor chip. Closed loop feedback systems have been installed on cars since 1980. An oxygen sensor is the heart of the feedback loop. Oxygen sensors are based on a ceramic solid state electrolyte that produces a voltage dependent on the difference in oxygen concentration inside the exhaust manifold and outside in the air.

Computer controlled fuel systems operate in either closed or open loop modes. Open loop operation means that no feedback takes place and oxygen sensor data is ignored. Cold starting and full throttle acceleration are open loop conditions. Under open loop conditions, vacuum and temperature sensors tell the computer to default to pre-set values. Under near steady-state conditions such as highway cruising at steady speed, closed loop mode is entered. The computer gets inputs from sensors, and based on these, primarily the oxygen percentage in the exhaust manifold, the computer instructs various actuators to adjust the mixture to maintain the exhaust oxygen level best suited to efficient converter operation. In the process of doing so, high fuel efficiency is also achieved. This closed loop mode works under steady speed and part throttle conditions including slight load variations and gentle acceleration.

Sudden deceleration or wide open throttle acceleration causes the system to leave closed loop mode and cut off or supply fuel based on inputs other than the oxygen sensor.

Computer control systems work with both carburetors and fuel injection, but the trend is toward injection. Feedback carburetors have stepper solenoid actuated mixture rods or variable venturis that make them almost as complex as fuel injection, and just costly.

EMISSION CONTROL TAMPERING

The high cost of replacement parts after the 50,000 mile warranty expires is a factor that leads to the removal, disconnection or other tampering by backyard greasemonkeys and a few commercial shop on an under-the-counter basis. In spite of fines of $10,000 from the EPA, people insist on ripping out converters and air pumps and throwing them away.

Before 1975 it was obvious that emission control parts were simply hung onto engines that had been in production since the 1960's or before. It was easy to remove air pumps and readjust the carburetor and distributor to restore pre-'72 performance and fuel economy.

After the 1975 debut of the catalytic converter, a new breed of tamperer crawled out of the grease pit. The catalytic converter was viewed with the kind of superstition, fear, and blind hatred that cave men may have had for flying saucers (had they seen any). Horror stories and rumors circulated about converters plugging up, melting floorpans and setting fire to several prairie states. Some people found out the hard way that putting leaded gas in a catalyst equipped car resulted in a plugged converter that choked the exhaust down so tight the car wouldn't run.

The catalytic converter was viewed with the kind of superstition, fear and blind hatred that cave men may have had for flying saucers (had they seen any).

The aftermarket parts people started selling pieces of exhaust pipe to eliminate converters about a week after the first converter equipped car rolled off the line in Detroit. The legal loophole that allowed the test pipes to be sold was that they were sold as a diagnostic aid, a tool for determining whether or not a converter was plugged and in need of replacement. Needless to say, 99.9 percent of all "test pipes" became permanent installations that enabled car owners to use leaded gas and save a few cents a gallon. Misfueling by the use of test pipes and so-called emergency refueling adaptors ran as high as 30 percent of all catalyst equipped vehicles, by some estimates.

Newer cars, say 1980 and up, with computer systems and electronic fuel injection are much less prone to tampering. The economic motivation to burn leaded fuel is no longer a factor since these engines rely on oxygen sensors which would be poisoned by lead. Removal of the oxygen sensor and the converter would make the car unrunnable without replacing the entire ignition and fuel system.

PREDICTIONS FOR THE FUTURE

A general trend toward more electronics, fewer serviceable parts and increasingly poor underhood access will continue. Diagnosis and repair problems will continue to grow as the high-tech hardware and electronics used to control emissions and run cars will continue to accelerate faster than the ability of the industry to train technicians, not just guys who install expensive parts until something works.

Computerized engine analyzers can't really diagnose defective parts. They can only narrow the search to a given subsystem or circuit. Today's computerized diagnostic toys just print out a list of everything that could possibly cause the symptoms they are presented with. The future will likely bring artificial intelligence and expert systems technology to the service bay. AI and Expert Systems will not replace mechanics, but make them faster and more certain of their diagnostic steps.

Improved catalysts, high-temperature ceramics and composites will play an increasing role in engine and vehicle design. Don't be surprised by five valve per cylinder engines with ceramic pistons and polymer blocks. Don't laugh; the Japanese have built a ceramic block diesel that runs on sunflower oil.□

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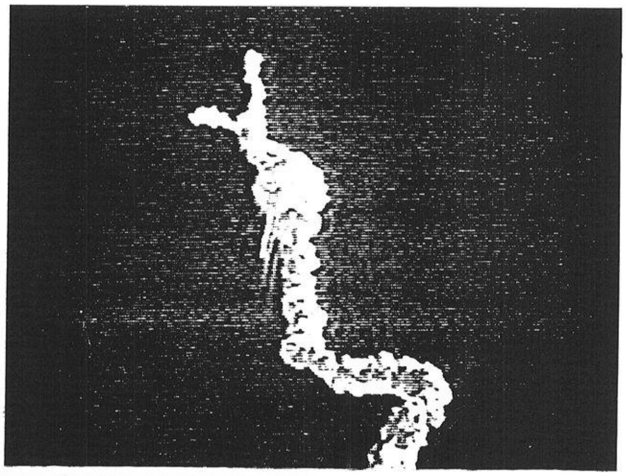
Ethical Decisions

By former MTI engineer Roger M. Boisjoly



Mr. Boisjoly's speech is continued from the February "Wisconsin Engineer." —Ed.

We all gathered at MTI's resident office in Washington D.C. after the testimony on February 25th, and feelings were very tense once again. The intensity of bad feelings was so great that someone in MTI management suggested that the company jet immediately take us back to Huntsville, Alabama as soon as we gathered our belongings from the motel. However, eventually cooler heads prevailed and we were told that we could spend the night in Washington, D.C. and catch a commercial flight the next morning. Later that same evening, MTI management decided to send me back to Utah and keep Arnie Thompson at MSFC until the failure investigation was completed.

I was happy to return home because I wasn't pleased with the way NASA management was diligently attempting to find a condition other than low temperature which caused the disaster. In Utah I began to sense the first signs of isolation from NASA, but I didn't fully recognize the situation. I continued to argue for full truthful disclosure, while factions of MTI and NASA management were fully content to tell only half-truths about the history of the development and production of the solid rocket boosters.

I realized in mid-April that I was being isolated from NASA and the main redesign activity since mid-March, while MTI management was telling me of my importance to the redesign. Unknown to me, Ed Garrison, the President of Aerospace Operations at MTI, had ordered that I should be kept from contact with NASA. This was done with great subtlety, so the company could say if asked, "Yes, Roger Boisjoly still works here; in fact, he's the new Seal Redesign Coordinator."

Conditions kept deteriorating for some of us who had testified. Once again we were called to testify before the Presidential Commission in closed session on May 2, 1986. During the evening of May 1, we met with Mr. Garrison at our Washington D.C. resident office. Mr. Garrison opened the meeting with a few general remarks about the upcoming session with the Commission the following day and then he addressed me. He chastised me for airing the company's dirty laundry via my memo, which I had given to the Commission. He also stated that MTI had suffered enough as a result of public disclosure, but that we should continue to tell the truth—making sure to consider the best way to state it before speaking. I quickly took exception to his remarks about me and said that I had simply tried to restore the truth in all testimony and that I did not consider my actions as "airing dirty laundry." Bob Ebeling then spoke up with some support for me and told Garrison that MTI should have a specialized engineering development group. Garrison snapped at Bob and told him to quit telling him how to run the company. We went into the Commission session the next day with conditions as tense as they had ever been, and Chairman Rogers asked Al McDonald, Director of the SRM Project at MTI, and me about our current job assignments. We answered him; he was visibly upset because we were being punished for honesty in our own testimony. When the Commission decided to make the closed session testimony public, MTI received tremendous criticism from the Congress, the Presidential Commission and the news media.

A few days later, Mr. McDonald and I were invited back to Washington by the Presidential Commission to review and comment on the final Official Accident Analysis Team Report which was submitted to them by MSFC. The Commission had somehow found out that neither Al nor I had seen the final report. I submitted 12 pages of comments on the report and gave verbal testimony to four Commission members that the report findings were biased—I saw an attempt to downplay the effect of low temperature on the joint failure by trying to first focus blame on such things as assembly problems and other areas. The Commission agreed with our comments and thanked Al and me for our willingness to review and comment on the report on such short notice.

Major morale problems now started to develop on the program as some of our colleagues perceived that our testimony was causing damage to the company. We didn't agree at all with that assessment, and decided to correct it by requesting a meeting with the three top executives who could do something about the internal strife. A private meeting was held on May 16 with Charlie Locke, the CEO, Ed Garrison, the President of Aerospace Operations and Ed Dorsey, the Vice President of the Shuttle Program. The meeting produced a very candid discussion from our side but it was essentially one-sided, with management telling us very little. The CEO even made it sound like we were on probation, and if we worked hard and proved ourselves during the redesign

activity, then everything would be forgiven. His attitude was certainly consistent with his criticism of Al and me in his previous statements to the "Wall Street Journal." I believe it was at that meeting that the CEO made the statement that the company was doing just fine until Al and I testified about our job reassignment on May 2. He said that those statements caused the company more harm than all the previous releases up to that time.

Al McDonald and I were supposedly restored to our former positions after MTI was scolded by some very angry U.S. Senators, but the restoration was actually only superficial. The company, by inference, skillfully reported a promotion for Al McDonald, who was to head the redesign activity, as well as the restoration of my interface with NASA. Apparently, the press release was taken as gospel by the news media, because they all reported that Al was given a promotion and I was given back my former job. Actually, Al got only his old job back without a promotion, while some people who had remained silent got promotions. The same people who wouldn't face up to the original bad joint design were directing the joint redesign effort. Simply put, the joints were redesigned by top management, with direction down to the working level engineer, who is trying to engineer the details to make it work.

I had been chastised and criticized before my colleagues and ignored generally, both personally and technically, but I still tried to make my voice heard for the best joint redesign. I was the only person that reviewed the proposal submitted to MTI by Vetco Gray Company of Houston, Texas, and finally secured them a chance to present their proposal to MTI management, but unfortunately for Vetco Gray the primary redesign configuration decision had already been made, and they had only a poor backup position at that time.

Al McDonald, Arnie Thompson and I along with MTI management were asked to testify at the house of representatives committee on science and technology hearings on June 17 and 18, 1986. The two days of preparations with attorneys and public relations people plus the testimony itself was almost more than I could withstand, when combined with my treatment at MTI.

Approximately one month after my testimony to the house committee, I could no longer endure the hostile environment at MTI, so I took some time off at the recommendation of a company executive. During this period of being away from MTI, I realized that I could no longer work for them and I so informed them that I would not return to work. I was placed on extended sick leave from July 21, 1986 until January 18, 1987, at which time I qualified for long-term disability. I currently receive 60 percent of my former salary, which will end January 18, 1989.

This all leads to a single question: what is the professional responsibility and ethical conduct code which should be practiced in the workplace? The following advice was given by Mr. Adolph J. Ackerman in June, 1967 in an article published by the Institute of Electrical and Electronics Engineers (IEEE). Mr. Ackerman said, "Engineers have a responsibility that goes far beyond the building of machines and systems. We cannot leave it to the technical illiterates, or even to literate and overloaded technical administrators to decide what is safe and for the public good. We must tell what we know, first through normal administrative channels, but when these fail, through whatever avenues we can find. Many claim that it is disloyal to protest. Sometimes the penalty—disapproval, loss of status, even vilification—can be severe. Today we need more critical pronouncements and published declarations by engineers in high professional responsibilities. In some instances such criticism must be severe if we are to properly serve mankind and preserve our freedom. Hence it is of utmost importance that we maintain our freedom of communication in the engineering profession and to the public. The decades ahead are bound to be a critical and difficult period, and there will be occasions for sharp dissent and strong words if we are to meet our responsibilities."

In a parallel vein, the American Institute of Aeronautics and Astronautics (AIAA) has published a code of ethics for its members, known as rule 2.4, which states, "The member will indicate to his employer or client the adverse consequences to be expected if his judgement is overruled." I believe that we as professionals must voice our technical opinions in a clear manner to the decision makers, whether our views are good news or bad news.

The academic community has studied many cases on whistle-blowing and ethical conduct in our society and have some conclusions which apply directly to this discussion. The following quotes were published in the February 1987 IEEE "Spectrum" magazine. Professor William H. Starbuck of New York University's Graduate School of Business Administration said, "The fact that people are in a hierarchy tends to amplify misperceptions. A low-level person has a fear that something might happen and reports it to a higher level. As it goes up the hierarchy, information gets distorted, usually to reflect the interest of the bosses."

Professor of communications at Boston University, Otto Lerbinger states that corporate cultures try to ignore the unpleasant, and a trend that has to be counteracted by corporations deliberately creating a culture that encourages people to bring up unpleasant information. He also states, "In a group trying to move ahead with a decision, you find that those people that have anything negative to say are unpopular, so a manager deliberately has to encourage people taking the devil's advocate position. In a crisis situation, somebody has got to think about the possibility of something going wrong, and to use a worst-case scenario approach."

Professor of Sociology at Smith College, Myron P. Glazer said that time and again there is the tendency to kill the messenger bringing the bad news, rather that punish the wrongdoers. He also states that, "People who hung tough with their organization managed to do very well. Hanging in there and not protesting is valued highly. They manage to survive because of their fundamental and correct belief that the organization will protect them."

The research on the subject of whistle-blowers shows that they first attempt to achieve problem resolution through their organizational chain of command and then are punished by the organization after whistle-blowing outside it.

I testified to the Presidential commission that I made clear to MTI and NASA managers my engineering position about the consequences of launching in such cold weather, but then I felt helpless as they ignored my input and decided to launch anyway. A NASA (MSFC) colleague of mine, Ben Powers said, "You don't override your chain of command. My boss was there; I made my position known to him; he doesn't have to give me any reasons; he doesn't work for me; it's his prerogative." I hope that everyone can understand from these statements that all the engineers who spoke out against the Challenger launch followed the same communications path that the researchers found in all cases, i.e. their normal organizational chain of command. We also have been punished in varying degrees for our testimony to others.

Now I must state that all of you must evaluate your careers and emerge with the knowledge and conviction that you have a professional and moral responsibility to yourselves and to your fellowman to defend the truth and expose any questionable practices that will lead to an unsafe product. Don't just sit passively in meetings when you know in your heart that you can make a constructive contribution and also be prepared to share your ideas with others and to compliment others for their ideas, especially when their idea is better and may even replace yours. This is the best way to cultivate colleague or peer respect and friendship, which in industry always results in a positive long- term benefit for you, the company and its product line.

I wish that the Challenger disaster had never happened, but since I cannot turn the clock back, I hope that if anything good can result from this tragedy, then I desire that all academic institutions and professional societies will recognize the importance of teaching ethical behavior in decision making situations by using actual case histories like this one to demonstrate what was wrong so everyone is aware and prepared for what to expect when confronting a situation requiring an ethical decision.

I have been asked by some if I would testify again if I knew in advance of the potential consequences to me, my family, and my career. My answer is always an immediate yes. I couldn't live with any self respect nor expect respect from others if I tailored my actions based upon potential personal consequences resulting from honorable actions. As a result of this talk and other exposures to real case histories, I hope that your answer will also be yes if you are confronted with a similar decision.

I have filed a billion dollar lawsuit against MTI and a ten million dollar lawsuit against NASA, as well as a false claims suit against MTI on behalf of the US Government. First, my intention is to secure compensatory damages for my lost salary and ruined career. Second, I hope the suits send a serious and significant message to MTI in particular, to executives of other companies, and to government agencies that they cannot make arbitrary decisions that kill people and ruin the lives and careers of employees without accountability. I hope and expect drastic improvement in ethical decisions and employee treatment for promoting ethical conduct.

I will never forget, and I hope this nation will never forget, the supreme sacrifice that the seven Challenger astronauts made for such an irresponsible launch decision. May we always remember astronauts Scobee, Smith, McNair, Onizuka, Resnik, Jarvis, and McAuliffe for their courage and dedication to this nation's space program.

Maybe together we can all accomplish the second goal in my lawsuits and eliminate all unethical decision-making practices within our industrial and government communities.□

The Wisconsin Engineer Magazine Presents...

Ethical Decisions:

Morton Thiokol and the Space Shuttle Challenger Disaster

By Former MTI Engineer Roger M. Boisjoly

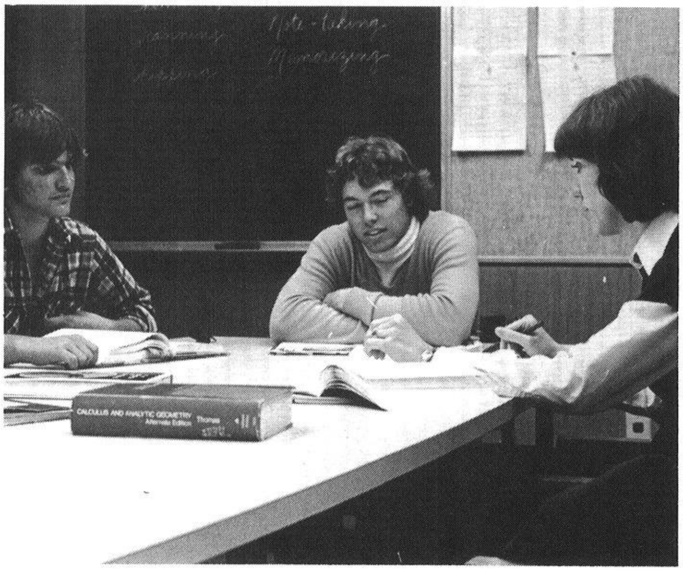
Rm. 159 Mechanical Engineering

May 2, 1988 7:30 p.m.

Reception will follow.

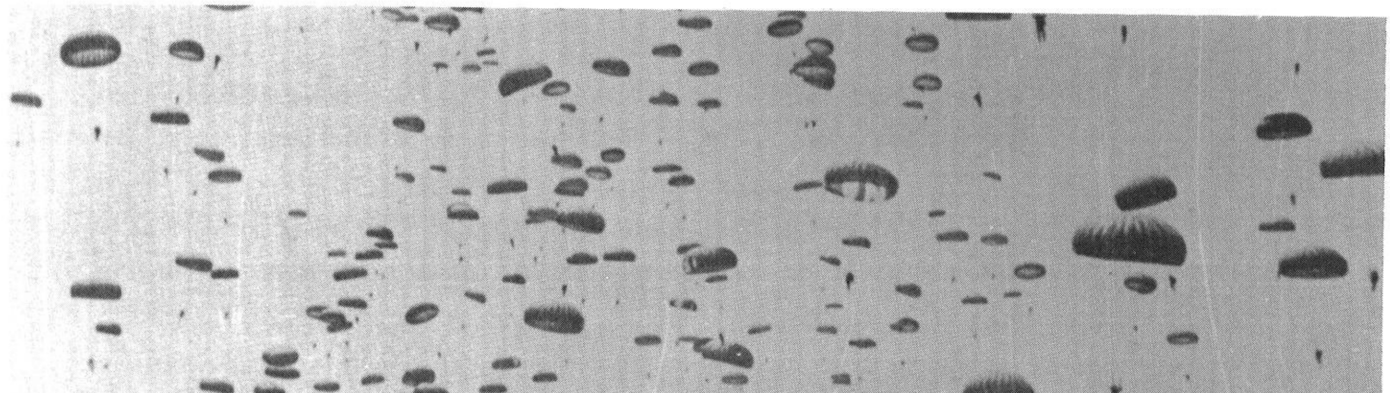
Just One More

by Jeff Molter

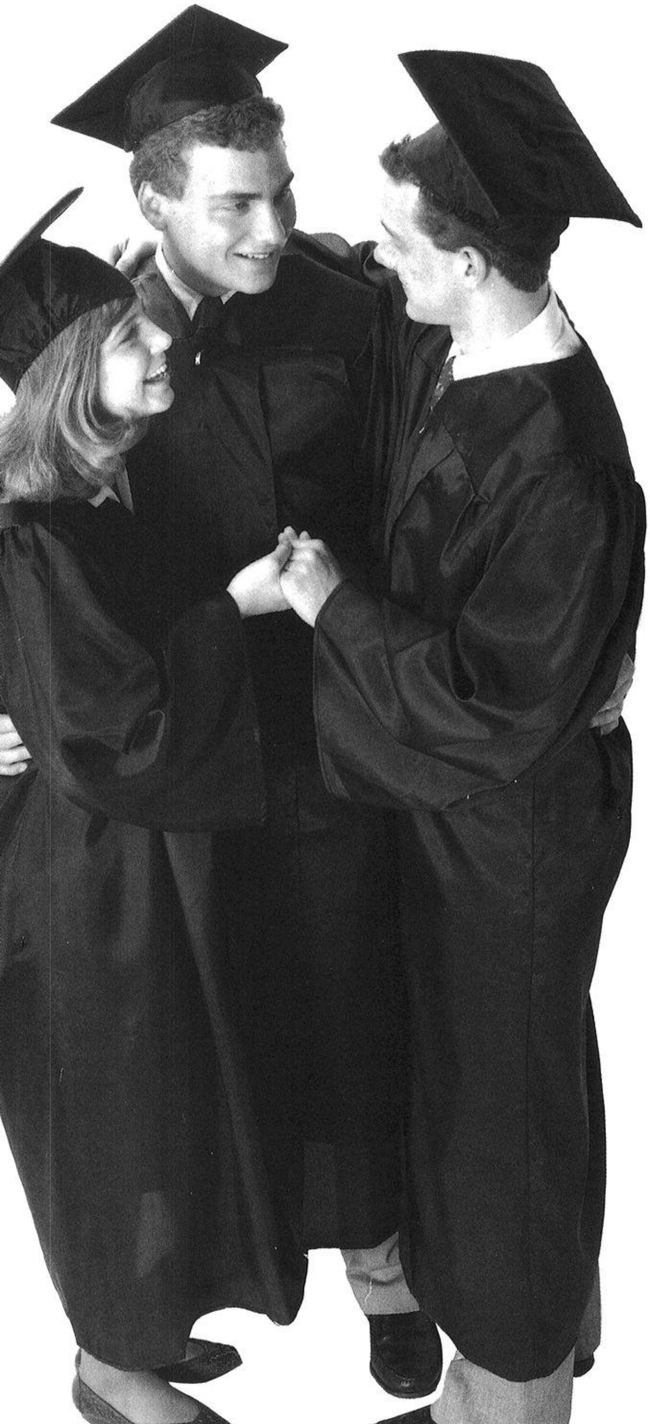


Are you as tired of studying as this guy is? If so, then you should consider joining the "Wisconsin Engineer" parachute team, climaxing with a jump from 180,000 feet.

As you near the jump point, the view looks just like this. This is when the adrenalin really starts to pump through your veins.



Miraculously, on our last jump, all 200 of us landed in the same Wisconsin cornfield. If you're ready to have the most exhilarating experience of your life, join us, the "Wisconsin Engineer" parachute team.



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When you graduate, you say "goodbye" to one lifestyle and "hello" to another. You leave some old "friends" behind: college roommates, your best worn bluejeans, your all-night library pass.

But there's one old friend you don't have to say "goodbye" to: The University of Wisconsin Credit Union.

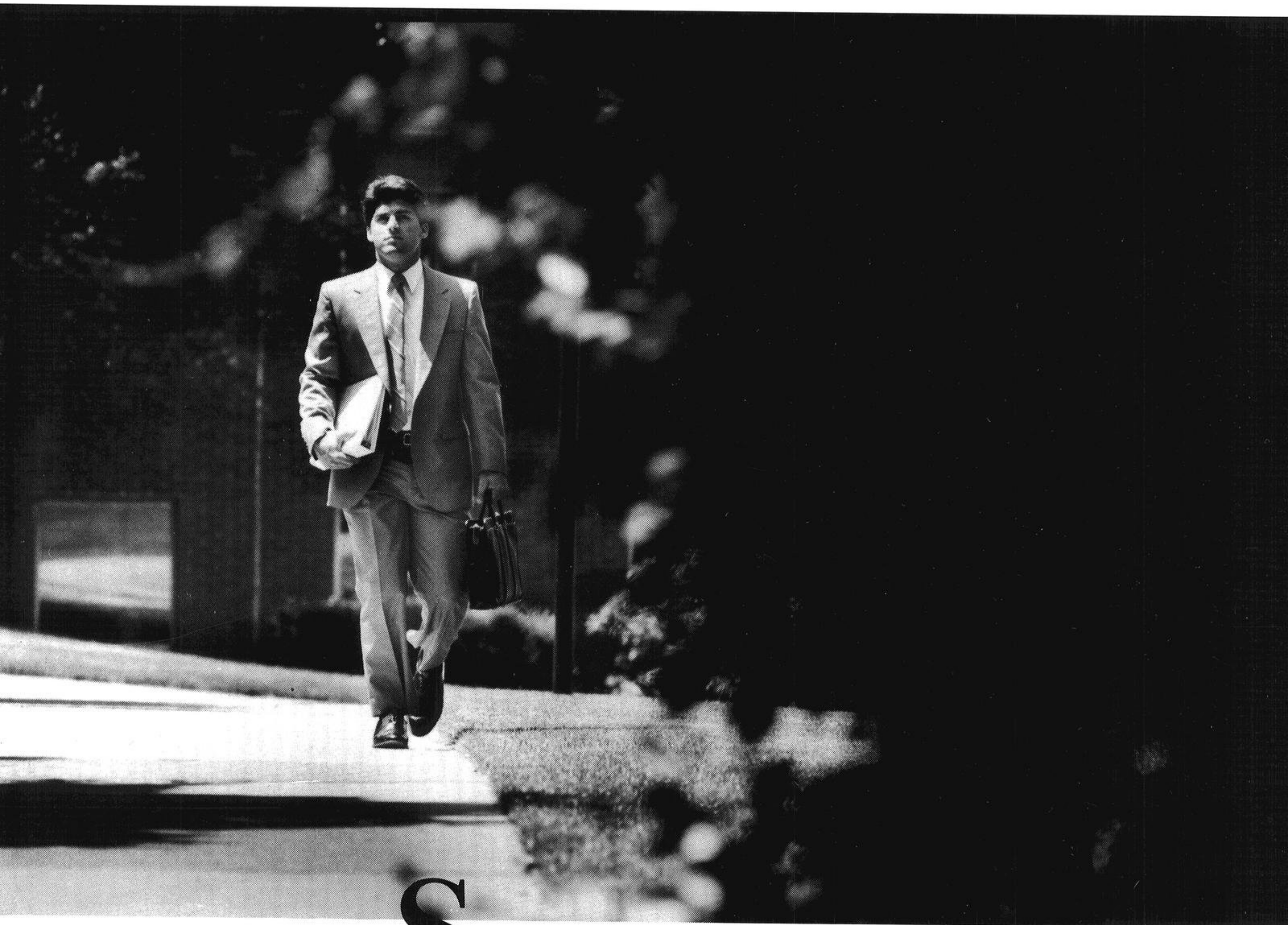
Whether you're staying in Wisconsin or moving across the country, our services can travel with you: pre-approved loans for your new car; low-cost MasterCard and VISA credit cards; checking accounts with TYME; Money Market accounts; Savings Certificates, even IRAs. Our "member•friendly" services will make your transition from student life a little less painful.

If you're not yet a UW Credit Union member, investigate the benefits waiting for you today. Remember, even if you're no longer a student, the UW Credit Union is ***your*** financial. Stay with an old friend—for life.

University of Wisconsin Credit Union

Home Office: 1433 Monroe Street, Madison, WI 53711
Madison: (608) 262-2228 Milwaukee: (414) 332-2300
Green Bay: (414) 465-2345 Whitewater: (414) 472-1031

Rob Bongiorno hardly ever shows up at the office.



Staying out of the office is a big part of Rob's job. He's out in the marketplace working with customers. That's what he likes and does best.

Rob is in GE's Technical Sales Program, an 18-month leadership experience for engineers with strong interpersonal skills. It's a great choice for technical people who want to provide solutions to customers' problems.

Rob stays on the leading edge. He anticipates change in highly competitive markets. He responds to customers with creative problem solving. His efforts are supported by resources that only a multi-billion-dollar company can offer.

On top of all that, Technical Sales has put Rob on track as a potential leader of GE. Did you ever think staying out of the office could make someone look that good?

GE

The mark of a leader.

An equal opportunity employer.