DEAN’S MESSAGE

In this issue of Engineering Review, we look to the future. Who will be our students and what will be the issues that they will have to address? Global warming, pollution of our water and air, and safe disposal of the chemicals used by industry are but a few of the issues these students will face in the 21st century. The growing concern for the environment is inevitably linked in the minds of academia to how to teach students of the 1990s and beyond to cope with these issues.

At a recent conference at Colorado State on strategic responses to global changes, U.S. Sen. Tim Wirth (D-Colo.) said, “We are on a collision course with the globe, and if we’re not careful and change our ways, that collision course will be disastrous to humanity, and it will be disastrous for civilization.” Sen. Wirth’s thoughts have been echoed in numerous scientific journals. Among the most recent are the October and November issues of Engineering Times, in which the writers address “...the challenge of developing technologies for the general welfare...” and “...a shortage of environmental professionals in the U.S. to tackle mounting concerns about the proliferation and treatment of wastewater and hazardous and solid wastes, and about cleaning and preserving the air we breathe, and the water we drink.”

Our cover introduces to you some engineers of the future at Colorado State — bright and energetic young women engineering students who, through their interests and abilities, make us confident that these problems and challenges will be met and hopefully solved. Feature articles describe some of the research currently underway in the College on a wide variety of environmental issues. Departmental reports focus on current research projects and accomplishments of the faculty. Finally, the alumni section features the acceptance speech made by Gerald Arnold, Class of ’26, at the Annual Alumni Banquet sponsored by the Dean’s Council at Homecoming.

I hope you find this issue of Engineering Review informative and enjoyable. If you or your organization has an interest in any of our research programs, please feel free to contact the college. A summary report of active research projects in 1989 is available to the public.

Frank A. Kulacki
Dean
THE CHANGING COMPLEXION OF ENGINEERING

I feel that the creation of a Women and Minority Engineering Program is part of a 'natural order of evolution' of engineering as it adapts to changes in industry, society, and its own requirements.

The Women and Minority Engineering Program was formally begun a few years ago when industrial representatives of the college's University/Industry Roundtable suggested the program to address the issue of the small numbers of women and minority students in the College of Engineering. David Martinez, director of the program and assistant dean for undergraduate studies, feels that it was actually conceived 100 years ago when the college was established at Colorado State.

The College of Engineering was created with the mission of preparing students for the field of engineering through preparation and study in the areas of math and science. Over the years, the curriculum and methods of instruction have been modified and changed to adapt to the tremendous advancements in technology to meet the requirements of industry and society. The changes that occurred in curriculum and the methods of instruction were seen as necessary and their value and benefit were self-evident. The evolution of engineering and the needs of industry and society required those changes be made. And so they were made.

As Engineering Education reports in its July/Aug. 1989 issue, "Women and minorities have been noted as the largest potential untapped source of engineering and science talent in the nation."

The College of Engineering would like to introduce you to eight promising undergraduate students who are members of this untapped pool.

Engineering, as an industry and a science discipline, is constantly feeding upon itself and, similar to a locomotive, requires continual stoking of its creative fire. The fuel it requires is the technology it creates and the

Traveling the Road to Success
JACQUELINE DOWDS

Jacqueline Dowds began preparing for an academic career early in life. As a 7th grader, she was on the advanced track for math, science, and English. This preparation in junior high enabled her to take advanced placement courses in English, chemistry, and calculus in high school. She could thus enter college with many of the required courses under her belt.

As a freshman in college, Jackie won first place in the Engineering Days "Overall Civil Engineering" category for developing a computer program that simulated an elevator. The program accounted for the time it took for a person to walk in the front door of the building, stand in line for the elevator, and be delivered to a floor. Based on her early successes, she intends to pursue a career in the area of structural engineering. "I am interested in designing large, one-of-a-kind projects like bridges and dams and perhaps working on highways and interstate interchanges."

Jackie is a junior majoring in civil engineering, with a minor in mathematics. "I came to Colorado State because the campus seemed to have a friendlier atmosphere and seemed more homey, and was more of a personalized place."

An active member of the Society of Women Engineers, Jackie is currently president of the Colorado State SWE chapter. "SWE has helped me to develop leadership and public speaking skills. When you are in front of the group and trying to get them to be involved, you learn how to be tactful and how to encourage them to participate." Jackie is also a member of ASCE and Hesperia, a campus-wide honors society and service organization whose members assist the Salvation Army in their soup kitchen and with planning a Christmas party for orphans and underprivileged children.

Is she happy to have chosen a career in engineering? Jackie responds, "I think women in engineering is a very positive thing. We are equally capable and it seems perfectly natural to work with men in this area. I have never experienced any discrimination while attending Colorado State and feel that there is a lot of support for female engineering students in the college as well as the industry. Now is the prime time for women to enter engineering!"

JENNIFER ARCHIE

Jennifer Archie chose to major in engineering science with a software systems option so that she could combine her many interests into one job. "I like art and foreign languages. You can incorporate art into engineering technology, such as going into..."
The ENVIRONMENT & COMPUTERS

graphics or automotive design. The art just increases your creativity in engineering.

“Software systems option is computer-oriented — designing a software program in order to solve any problems that you may have such as designing databases to store information that an organization may need. In my major, you don’t have to follow the guidelines; you can practically make up your own major. You can incorporate your other interests into the field.”

Although she did not like science and math in junior high, a Horizons Upward Bound summer class in computers, offered at a private school in Michigan, gave Jennifer a new direction. “I was introduced to computers by my mother. She brought a computer home, and I was the only one in my family who latched onto it and figured out how it worked. That was the stepping stone, and when I took the computer basics class, it furthered my interest in computers and engineering.”

She entered college with scholarships from her private school and the Detroit Board of Education minority mentor program. Jennifer also works part-time in the engineering computer laboratories, assisting students and faculty with writing programs for class plotting graphs and writing databases for research projects. She is trained in the use of the sophisticated graphics computers, which can be used to create moving, animated figures, robotic arms, and mechanical hearts.

A junior this year, Jennifer is considering her employment opportunities. “I would like to work with a company that is not in the mainstream and that likes to be creative, developing new concepts and technologies. When I was in high school I read about home automation, like the Jetson’s TV show, and I think that sounds like fun.”

SAMARA IODICE

In high school, Samara Iodice set two very definite goals for herself. She accomplished the first one: she was named valedictorian of her graduating class. Her second goal, to attend college in a pre-veterinary medicine program, has been slightly altered. Upon entering Colorado State, Samara discovered that a major in agricultural engineering would provide her with the background she needed for veterinary school. She chose this route, but in the summer before her sophomore year decided that agricultural engineering was her chosen field after a company in Denver offered her summer employment to work on a hazardous waste project.

“I am really interested in the new technologies that are being utilized in the hazardous waste industry. I am especially interested in bioreclamation, which involves the biodegradation of contaminants in soil by microorganisms. These microorganisms are found naturally or are introduced by inoculation. At the company where I worked, I studied a site at which railroad ties had been treated with creosote, causing various oil-derived contaminants to leach into the soil and ground water. The company used bioreclamation in a pilot scale study to determine what kind of clean-up level could be achieved.”

In addition to her academic achievements, Samara was concert mistress for her high school orchestra and was chosen to play in All-State Orchestra. She has maintained her outside involvement in college, and is a member of the Society of Women Engineers, the American Society of Agricultural Engineers, and the Society of Animal Awareness.

A native of Florida, she has adapted well to her new environment. “I knew I wanted to come to Colorado and was afraid, because I did not come to Preview and thought I would be in a hick town. I was surprised to find things I recognized. Fort Collins is a perfect town — coming from Florida where it’s so hot and flat, and where I came from seemed like all city. I love the atmosphere here and the friendly people.”

What goals has Samara set for herself now? “I would like to go into the Peace Corps when I graduate, rather than taking a job right away.”

MARY WILLIAMS

Mary Williams is one of our most scholastically active students, majoring in civil engineering with a second major in physical science and minors in mathematics and chemistry. She is in her fifth year and will complete her program of study in May. A math major when she first enrolled at Colorado State, Mary changed to pre-med and then to engineering without losing her momentum.

Starting out with a good GPA during her freshman year enabled her to maintain her academic standing. “My parents advised me to keep my grades up my first year, no matter what else I did in school. I took calculus in high school and a number of advanced placement courses, which were great because they gave me a year to play with, since they counted for credit. I did not have to focus in during my freshman year on a specific discipline. If you have the opportunity to take an advanced placement course in high school, I recommend you take it.”

In addition to her heavy academic calendar, Mary is a member of the student chapter of the American Society of Civil Engineers and the civil engineering honor society, Chi Epsilon; current president of Tau Beta Pi, an all-discipline national honor society for juniors and seniors; and a member of Golden Key, a university-wide honor society.

Last summer Mary worked as a summer engineer for a national oil company. The experience convinced her to go into environmental engineering, because she was impressed with the company’s concern for the environment and the steps being taken to adapt its methods of operation to decrease the impact on the environment. Her plans are to continue her graduate education in water resources or environmental engineering.
TAMARA JOHNSON

Tamara Johnson, a senior majoring in civil engineering, says that being a woman was never a consideration in choosing her career. “My grandparents are both Colorado State alums, as are my mom and uncle. The way I grew up, I never thought of doing anything else but going to college. My mother is a chemist and thinks it’s great.”

Like many other engineering students, Tamara liked math and science in high school and was good at it. Not wanting to specialize in chemistry or biology, she chose engineering. “I want to go into space structures and structural analysis. I chose to go into civil engineering instead of engineering science with an aerospace emphasis because the aerospace industry is so focused, and when there is no money, I am out of a job.”

In her four years at Colorado State, Tamara has been actively involved with many of the student organizations, including SWE, ASCE, AIAA, Tau Beta Pi, and Chi Epsilon. She is currently president of Engineering Legislature. “One thing that is really important to me is that all the groups that I am a member of, I am an active member of. That’s one thing that I’m really proud of. It’s easy to say I have homework to do and can’t make a meeting every night of the week. And I do have meetings every night! It’s most important for me to be active than to say that I never go to anything.”

“I have put myself through school with scholarships and loans, and have tried not to have to work during school because, being so active, there is no way to keep a work, school, and meeting schedule. At school here I never felt out of place being a woman engineer, until I worked during the summer in industry. It definitely hit home that, on the broader scope, I am definitely still a minority in the field. I now know more of what I am NOT looking for in a company.”

ROBYN ALQUIST

Robyn Alquist graduated in December in chemical engineering, and is spending her spare time this semester in interviews with prospective employers. “I am focusing on companies who do biomedical research and produce products. They use the same equations, just different fluids. Instead of applying everything to a chemical plant, you are applying it to a human body.

“I was really good at math and science in high school, so my father and two uncles who were engineers told me I should be an engineer. I came in as ‘engineering undecided’ and decided on chemical engineering because of a textbook I read that had a case study about finding a membrane for a kidney dialysis machine that was thick enough so it didn’t break easily but permeable enough for the right fluids to go...”
OMMUNICATION DESIGN

through. I'm not interested in the typical chemical plant; I want to do something that affects people, and that seemed like a more practical people-oriented application. So since that class my focus has been biomedical engineering.

While at Colorado State, Robyn has been a member of AIChE and was chosen for the chemical engineering honor society, Omega Chi Epsilon, which she served as secretary/treasurer and later president. She is also in Tau Beta Pi, the honor society for engineering. "I've been involved in Masterpiece, a nondenominational Christian choir on campus. They tour and perform concerts in residence halls and churches."

To prepare her for her career, Robyn worked during the summers at Dow Chemical in Freeport, Texas. "I learned people skills in terms of applying your academic knowledge. But there is no way you can be the expert at everything, and you have to learn to use your people skills and use their expertise in the things that you are not very knowledgeable about. Life is not a textbook case, so it's easier to use practical experience from other people than to try to figure it out on your own."

MONIQUE MILLER

"I have always enjoyed trying to put things back together or seeing how things work," says Monique Miller, a sophomore majoring in mechanical engineering. "My Dad has always been one to say 'if you can fix it, go ahead' and has always pushed me in that direction."

Following her parents' advice, Monique began preparing herself early for a career in mechanical engineering. "I always took a math and science class every year in high school, which is above the requirements. Our school offered Junior Academy of Science, but basically I have always had engineering in mind. My grandfather also is an engineer, so I have been exposed to it all my life."

As a new freshman, the first thing she discovered was that she had to do everything herself. There was no one looking over her; she was on her own and had to adjust to living away from home. Because the class material in college is harder and more in-depth than in high school, Monique had to learn to manage her time. Monique chose to live on campus in the engineering dorm, Allison Hall, and has found a strong support-group among the co-eds in her dorm. "When you are having trouble with classes, there is always someone you can go to for help."

Her goal is to work in some area of design. One of the projects she was given as a freshman was to design a toy truck which would run off an airplane engine. The project included writing a proposal and making budget projections. Each team was given $50 to design and build a model and had to develop a time schedule to ensure they were finished by the project deadline. Progress reports were required throughout the semester. "It really helped a lot because if you start having doubts about if you want to do engineering, it helps to say this is how you can apply some of what you have learned."

GINA LEYBA

"My parents always encouraged me to go after what I wanted. They gave me the confidence that I could do anything I put my mind to," says Gina Leyba, electrical engineering major. A native Coloradan and junior this year, Gina has helped put herself through school with a two-year scholarship under the Kodak Scholars Program, and an accompanying summer internship. Her summer job at AT&T, which involved programming and using graphics software packages, gave her an idea of how she would actually be using her skills in the practical world. She hopes to apply what she learns to practical applications rather than research. "Right now I am looking into communications — signal processing and digital transmission."

At Colorado State she is actively involved with the Society of Hispanic Professional Engineers and is currently vice president of the student chapter. The goal of this group is to retain the Hispanics currently enrolled in engineering by tutoring and mentoring freshmen students. Members also spend time in the junior high schools, talking to students and encouraging them to take the math and science classes they need. "I live off campus, and it was hard to meet people, so my involvement with this club gave me the opportunity to meet other students."

"I think it's great to be part of the new growth of women in engineering. Since women are still considered a minority in this field, I think they need the same support as students from different ethnic backgrounds do in helping them to stay in school and deal with the pressures. Women in engineering do have more pressures on them — we get more attention, so you have to do better than just average work."

"The hardest thing I had to deal with is never having a female engineering professor. You do get used to it, but there is a difference." (Three percent of engineering faculty at Colorado State are female; the national average is 2 percent.)

In the July/August 1989 issue, Engineering Education reports that "Slightly more than half of today's college students are women, but they represent only 15 percent of engineering enrollment." With the recruitment and retention of talented and dedicated young students such as these, the College of Engineering hopes to turn these statistics around and provide society with the trained engineers it will need to meet the challenges of the 21st century.
BACTERIA BATTLE UNDERGROUND POLLUTANTS

Microbes in Training

Karen Reardon is among the new breed of biotechnology sergeants who are training microbial soldiers to attack groundwater pollutants. The soldiers are bacteria that naturally thrive on industrial waste; their battlegrounds are the nation’s polluted aquifers and soils.

Such biologically engineered water clean-up campaigns are known as bioremediation, which is fast becoming a promising technology for breaking down hard-to-reach pollutants underground or trapped in soil, says Reardon, the newest member of the agricultural and chemical engineering department.

"Bioremediation has real advantages over other techniques for dealing with a contaminated aquifer located from 10-100 feet below the surface. Since it's difficult to get down there, you can inject bacteria to do the job and supply them with nutrients at those depths until they clean up the site.”

Since the 1960s, companies have been increasingly intrigued by the thought of using microbes that have already developed a taste for toxic chemicals to battle environmental pollution. Some commercial labs have bred bacteria that can break down creosote, coal tar, solvents, and polychlorinated biphenyls (PCBs).

Oil companies view bacteria as viable weapons for cleaning up oil spills, Reardon said. Exxon recently distributed fertilizer on the oil-laden shoreline at Alaska’s Prince William Sound to stimulate the microbial clean-up of oil spilled from its Exxon Valdez supertanker. Sites treated with the fertilizer contained 30 times more oil-degrading bacteria than untreated areas, and the breakdown of oil appeared to be accelerated.

"Since it's difficult to get down there, you can inject bacteria to do the job and supply them with nutrients at those depths until they clean up the site.”

Reardon is studying bacteria, including some that normally can be found in sewage, to discover the environmental conditions and nutrients the bacteria need to best tackle bioremediation. This basic physiological background and metabolic information is crucial if bacteria are ever to be used routinely to clean up contaminants, Reardon says.

"My focus is on first learning the fundamental behavior of bacteria so we can know more about what affects the rate at which they will degrade pollutants. We will look at how we can improve the rate of degradation of contaminants in soil and water.”

Once this basic information has been gathered, Reardon will improve the use of microorganisms for two types of treatment: in-soil bioremediation and with bioreactors, which could be used to purify water before it enters a drinking supply. He is especially interested in reactors in which the cells are immobilized or fixed to solid particles that remain in the reactor.

Reardon is investigating the bacteria’s ability to degrade the plasticizer, diethyl phthalate (DEP). Plasticizers are added to plastic products to improve their elasticity, hardness, or resistance to heat, cold, and acid. "DEP isn’t as toxic as some other chemicals, but it is found in much of the environment. Seepage from hazardous waste landfills also can contain some nasty chemicals like DEP.”

Reardon also is looking at microbes’ ability, under varying conditions, to break down atrazine, a popular herbicide. He is nurturing the bacteria in soil in the laboratory and altering their levels of oxygen, nitrogen, carbon, salt, phosphorus, and other nutrients to see how their activity is affected.

Resilient bacteria are critical in bioremediation. Bacteria used to clean contaminated soil, for instance, must be able to defend themselves against native bacteria. "The microbiology of soil is very complicated. Protozoans are waiting to graze on bacteria, which may have no defenses. We have to know what qualities bacteria need to survive in soil.”

We will look at how we can improve the rate of degradation of contaminants in soil and water.

Another problem is that bacteria that are injected into compacted soil far below the surface may find scant supplies of the oxygen they need to thrive. "The oxygen levels even a few inches below the surface are quite low. If we have to use bacteria to clean up a spill 30 feet below the surface, it's a real problem maintaining oxygen levels.

"Companies have spent a lot of money pumping air down into the soil with limited success. The oxygen is often consumed very near to the outlet and doesn't reach all of the microorganisms.”

Reardon recently has been encouraged by his laboratory’s initial discovery of bacteria that could live with or without oxygen. The rate at which the organisms degrade chemicals isn't high but is still promising, he says.
Other promising findings are surfacing from other laboratories around the country, which bode well for finding permanent waste treatment and disposal solutions, he added. "The outlook is very good for bioremediation. The emphasis now is on cleaning up compounds with technologies that can permanently remove pollutants instead of digging up contaminated dirt and burying it in landfills, which doesn't solve the problem."

Reardon views Colorado State as a wonderful place to pursue his bioremediation work. "Many researchers in agricultural and chemical and civil engineering, agronomy, and environmental health have expertise in water movement, contaminant flow in soils and aquifers, and microbiology—all of which are related to my work."

Reardon's research is funded by the Agricultural Experiment Station.

By Susan Skog
illions of visitors feel the pull of the mighty Grand Canyon each year. They come to see the sweeping canyon walls, their multi-colored rocks marking more than 2 million years of geologic time. But today some visitors find the age-old views marred by a modern-day interloper—air pollution.

On certain winter days in the canyon, visibility is impaired by high concentrations of sulfates in the air. Until recently it wasn't known what caused the pollution; many pointed the finger at California's urban pollution. But with sophisticated computer simulations and several years of meteorological data, atmospheric scientist Roger Pielke and research associate Roger Stocker recently traced much of the Grand Canyon's occasional winter haziness to a local source—a coal-fired generating station 45 miles away in northern Arizona.

"We found definitive information that the Navajo Generating Station was a major contributor to the degradation of air quality in the Grand Canyon," Pielke asserts.

Having previously identified the type of meteorological conditions in the West under which air pollution in the winter is most pronounced, Pielke and Stocker drew their conclusions about the Grand Canyon's haziness after examining National Weather Service data. They also studied records of the high- and low-sulfate days in the region surrounding the Grand Canyon from 1982-88. More detailed air quality and meteorological data were gathered at collection points in southern Utah and northern Arizona in a six-week period during the winter of 1987.

Pielke and Stocker concluded that not only do the Navajo Generating Station's emissions reach the Grand Canyon, they also tend to be trapped under temperature inversions during the winter. "In the winter the Grand Canyon experiences its highest air quality degradation in association with polar high pressure systems. That's because such a system brings sinking air and light winds, which lead to temperature inversions and poor dispersion. In addition, when the polar high is centered northwest of the canyon, northeast winds can transport pollutants southwest toward the canyon."

With the canyon's complex terrain, the poor dispersion of pollutants can be compounded because air can become trapped within a canyon or valley, Pielke adds. "In the winter when the sun angle is low and snow covers the ground, the stagnation can be quite pronounced. In many areas in the Great Basin we have cold air that traps pollutants for six to eight days or even longer."

In February, the Environmental Protection Agency is expected to issue its initial recommendation for the amount of emissions that must be reduced by the Navajo Generating Station, says an official with the National Park Service's air quality division.

"Based on EPA guidelines, we suspect that they will ask for a 70 percent to 90 percent reduction in sulfur dioxide emissions," says Chris Shaver, chief of the Park Service's policy planning and permit review branch. EPA's final decision is expected in December, Shaver says.

Pielke believes that the type of visibility studies conducted in the Grand Canyon also could be completed for other national parks plagued with poor visibility. A former member of the Colorado Air Quality Commission, Pielke believes that his scientific work can give decision makers the concrete information they need to promote air quality in national parks. "I see that my contribution is to provide the best scientific input I can to regulators so they can focus on the policy issues."

In light of Pielke's findings, Shaver says the Park Service is taking a new look at the impaired visibility at other national parks. "We are starting to look at parks with large, nearby air pollution sources, which operate without control equipment to see if similar studies could be done. One thing that we learned is that local sources near parks can have a substantial impact on visibility under certain meteorological conditions," Shaver concludes.

RAMS is on the cutting-edge of computer models that can simulate atmospheric flows.
n a clear day, maybe you can still see forever in some pockets of the world. Hazy days, however, are a different verse. To help the National Park Service get a handle on haziness in national parks and urban areas, the Department of Atmospheric Science has studied the impact of pollution on visibility for almost 10 years, beginning with the work of now-department head Stephen Cox and Professor Tom McKee.

For the past five years, Professor Graeme Stephens has carried on much of the research, which relies on sophisticated computer models to simulate the impact of pollution, humidity and other factors on visibility.

"We provide the National Park Service with sophisticated models of the effect of aerosols and particles in the atmosphere on visibility. The Park Service has used the models to estimate the effects of pollution on visibility in the Grand Canyon and in other national parks as well as in urban settings like Chicago," Stephens explains.

The models, which are unique to the scientific community studying visibility, can simulate the effect of different-sized particles of varying compositions and chemistries on visibility, Stephens adds. "This is a unique capability that we have provided the National Park Service."

By Susan Skog
cross the country, thousands of coal-fired power plants, kilns, and smelters churn out electricity, cement, and minerals. But they also may be emitting fine particles of fly ash that can work their way into lung and heart tissue, spawning everything from asthma to lung cancer. Civil engineer Jane Davidson is working on some novel techniques to better capture the particulates before they escape into the environment.

With Environmental Protection Agency support, Davidson is working to improve electrostatic precipitators, used widely at power plants and other operations as air pollution control devices to collect fly ash. The precipitators separate the ash from surrounding gases when it is exposed to a high-intensity electrical field. Electrical forces carry the positively charged ash particles toward grounded metal plates to which they adhere.

"It's similar to separating the sand from water in a bucket. In this case, you simply let the sand sink to the bottom of the bucket," Davidson says.

"A precipitator accomplishes the same thing except instead of letting the particles sink under a gravitational force, they are driven to the collector plates with an electric body force."

Precipitators once were highly touted by industry and others as highly efficient fly ash collectors, capable of operating at 99 percent efficiency. But the problems surrounding the pollution-control technology now are coming to light, Davidson says. "Precipitators have had chronic problems and don't operate as advertised. I think that's partially because it's not truly understood how they do operate."

In the early 1980s, Davidson and other researchers began to show that precipitators were effectively capturing larger particles, while small micron-sized particles that can cause lung disease and breathing difficulties were often escaping, she adds.

"When you hear people talk about precipitators that are 99 percent efficient, which sounds phenomenal, they are talking about collecting 99 percent of the mass. That means that if you have a very large particle, like a rock in a bucket of sand, and you manage to take it out, then you've taken 99 percent of the mass. But you have still left a major portion of the particles."

Precipitators have had chronic problems and don't operate as advertised.

Much of the problem stems from the precipitators' outmoded design, Davidson says. The Greeks were among the first to explore the concept behind precipitation; the first successful commercial precipitators were installed in two California chemical plants in 1907.

Since then, the standard precipitator design has remained the same, Davidson says. They typically consist of up to 40-foot-high parallel metal plates suspended about one foot apart. Hinged between the plates are high-voltage wires, which promote the electrical field needed to ionize the fly ash particles and move them toward the negatively charged plates.

But in the precipitation process, the electrical forces create vorticity and turbulence. Swirling eddies of air, known as corona winds, mix the particles and hamper their migration to the plates. Instead of reaching the plates, fine particles are drawn into the electro-hydrodynamic flow and many escape into the atmosphere.

"The particles don't move nicely to the plates. They are struggling to get there. We would like to avoid that struggle. You can think of it as a dust storm. If you have something creating a swirling motion, it's the very fine particles that get caught up in that motion."

To improve electrostatic precipitators' ability to collect fine particles, Davidson has modified their standard design. Davidson and graduate student Peter McKinney are testing two new designs, which evenly distribute the electrical current and reduce the particle mixing. Their precipitators are based on a barbed-plate design without wires.

If you could retrofit a precipitator with a new barbed plate, it would be much less expensive than buying an entirely new system.

Davidson and McKinney are modeling one section of their precipitator in a specially constructed wind tunnel at the Engineering Research Center, located on Colorado State's foothills campus. Davidson now is testing the new precipitator in the wind tunnel with a laser Doppler to see if the barbed plate design improves the collection of sub-micron-sized particulates.

Since precipitators are extremely expensive and riddled with operational problems, Davidson hopes that her work could lead to possible retrofitting and improvement of existing precipitators. "If you could retrofit a precipitator with a new barbed plate, it would be much less expensive than buying an entirely new system."

By Susan Skog
LASER-LIGHT FLOW VISUALIZATION

- Precipitator flow in the absence of corona
- Transition to EHD flow in the wire-plate geometry
- Fully developed EHD flow in the wire-plate geometry
- Single EHD jet in the barbed plate geometry
talking the source of groundwater pollution can prove as elusive as searching for clues in a good murder mystery. As in many criminal investigations, engineers are finding that re-enacting the crime, or re-releasing chemicals into underground aquifers, might be the best way to crack the mystery of how many water supplies became contaminated in the first place.

Colorado State agricultural and chemical engineer David McWhorter and researchers from seven other universities are intentionally releasing chemicals into an already heavily contaminated Canadian aquifer. Their aim is to pinpoint how pollutants entered and moved through many groundwater supplies worldwide and now may be better cleaned up. The research project is the most in-depth field investigation of groundwater contamination of its kind.

Clues to how pollutants first entered many major aquifers are scarce, which sadly hampers clean-up efforts. In many cases, numerous pollutants mix together and make a hazardous concoction, which is hard to identify and treat. New clues about chemicals’ underground behavior should come to the surface with the investigation of the Borden Aquifer, located about 60 miles north of Toronto, McWhorter says.

“In our field experiments we can control the chemical release so we know exactly how much is released, and the rate and location of the release. In every case of contamination that I know about, none of these things are ever known. We always have a variety of possibilities but nothing concrete.”

In our field experiments we can control the chemical release so we know exactly how much is released, and the rate and location of the release.

McWhorter and his colleagues are specifically trying to better understand how chlorinated solvents may have fouled many groundwater supplies. Used in everything from dry cleaning to auto repair clean-up, solvents are among the most widespread chemicals found in contaminated water supplies, McWhorter says. They may persist for decades and even centuries.

To trace the path that solvents take in ground water, McWhorter and his fellow researchers have released chlorinated solvents into the Borden Aquifer. The aquifer is located on a military base and is one of the better studied aquifers in the world, McWhorter explains.

To precisely monitor the flow of contaminants in ground water, known as contaminant transport, the team of researchers released solvents into a carefully isolated 30-by-30-foot section of the aquifer. Water was injected at one end of the section to simulate ground water movement. Solvents then were released so they could flow downward and dissolve into the flowing ground water.

“We wanted to be sure we built reality into our experiments, so we can see how the solvent moves in a real groundwater system. Studies conducted in a laboratory may miss the important influence of naturally occurring phenomena like the layering and subtle changes of texture of the aquifer’s geology.”

Now the solvents’ behavior is closely monitored. One thing is sure; it will defy prediction. “We know the solvent will behave in some erratic way. From the surface, we would like to see if we can make some reasonable estimates of where it goes.”

A massive amount of work needs to be done on this problem ... You couldn’t ask for a more exciting research project.

Layer by layer, thin portions of the aquifer will be excavated near the release. They will be photographed to determine the paths the solvents took as they moved through the ground water.

If he and his colleagues can understand how solvents behave in ground water, they can give new impetus to contamination clean-up. Only about 27 of the more than 1,200 Superfund sites have been cleaned up. Solvents are especially vexing to tackle because they don’t fully mix with ground water but can dissolve enough to flow through
the system and pose a health hazard, McWhorter says.

"They sink to the bottom of the aquifer in the most remote parts and seem to do so in an erratic and unpredictable way. So their presence is very difficult to identify and do anything about."

McWhorter finds the complexity of solvent contamination makes for a challenging mystery that he hopes to help solve. "A massive amount of work needs to be done on this problem. In addition to the faculty researchers, we have 20 graduate students working on this effort. You couldn't ask for a more exciting research project."

The $3-million, four-year project includes researchers from the University of Waterloo, Colorado State University and the Oregon Graduate Center. Collaborators come from the University of Western Ontario, UCLA, University of Buffalo, and University of California-Berkeley. The project is funded by private companies including General Electric, Dow Chemical, Ciba-Geigy, Eastman Kodak, and agencies of the Canadian government.

By Susan Skog

Construction of the sheet-pile walls of the experimental cells at the Borden field site near Barry, Ontario, Canada

Preparing for release of organic chemical at Borden field site
Municipal wastewater treatment is a multimillion-dollar issue for many Colorado cities. After examining up to 30 years of average and low streamflow records along the Front Range, a Colorado State civil engineer finds that additional investments in wastewater treatment may be needed to meet federal water quality standards.

Streamflows often aren’t sufficient to dilute un-ionized ammonia concentrations downstream of Boulder, Fort Collins, Littleton, Englewood, and Longmont, finds Tom Sanders. Leader of the college’s environmental engineering program, Sanders recently conducted low-flow analyses near these cities in a research project entitled “Evaluation of Design Flow Criteria for Efficient Discharge Permits in Colorado.” Representatives of the Environmental Protection Agency, Denver Regional Council of Governments, the Colorado Water Quality Control Division and several other cities also served as steering members for the project.

“Our work showed that many areas in the Front Range won’t have enough dilution during low-flow periods to dilute ammonia concentrations to safe levels for fish downstream,” Sanders says.

“With existing water-quality rules, our research shows that all the cities we looked at will have to go to some tertiary treatment for part or all of the year to meet downstream ammonia standards to protect fish and other aquatic life.”

Our work showed that many areas in the Front Range won’t have enough dilution during low-flow periods to dilute ammonia concentrations to safe levels for fish downstream.

The data used for Sanders’ study consisted of U.S. Geological Survey streamflow records and other flow data from four Colorado rivers. Flow analyses of the South Platte River were made at Littleton and Englewood and Henderson; the Boulder Creek flows were analyzed above the city’s wastewater-treatment facility. Flows of the St. Vrain Creek were studied at Lyons, Longmont and Platteville, and the Cache La Poudre River was analyzed in Fort Collins. Further studies were done of the effluent limits based on municipal wastewater-treatment facilities at Littleton, Englewood, Boulder, Longmont and Fort Collins.

Sanders initially thought that his research would show that these cities might be able to cut back on their future treatment requirements and costs because of the normal dilution capabilities of area streams. “I initially thought that our water quantity requirements were too restrictive but found instead that our ammonia concentrations would be too high during periods of low-flow.”

Boulder has already upgraded its wastewater-treatment facilities to meet the downstream ammonia standards, Sanders says. Others will have to follow suit, he predicts.

“Unfortunately, unless changes are made in the water-quality standards to recognize the use of Colorado’s rivers for irrigation and municipal withdrawals, most Front Range cities will have to go to intermittent or continuous tertiary treatment for the entire year.”

This research was supported by the City of Aurora, Mission Viejo, City of Glendale, Metropolitan Denver Sewage Disposal District No. 1, Englewood/Littleton Bi-City Waste Treatment Plant, Larimer-Weld Regional Council of Governments, U.S. Environmental Protection Agency, Public Service Co. of Colorado, Colorado Water Quality Control Division, Colorado Water Resources Research Institute, and the City of Boulder.

By Susan Skog
Dr. Tom Sanders sampling the Cache la Poudre River at low flow.
Surviving the Agricultural Crisis

Expert systems are computer programs that use knowledge derived from human experts to solve problems. Consequently, expert systems mimic the problem-solving processes that a human expert would use. Some scholars claim that by emulating human reasoning in its ability to combine objective and subjective knowledge, expert systems can expand both our capabilities and the availability of specialized expertise. Expert systems are composed of a knowledge base derived from human experts, an inference engine, and a user interface. Expert systems differ from traditional computer programs in the knowledge they contain and the way a recommendation is obtained. Expert systems rely on declarative information and experience-based knowledge rather than the number-crunching style of conventional programming. Knowledge-based expert systems are well suited to applications in agriculture because they can be designed to handle the uncertainty and incomplete knowledge associated with weather and crop behavior.

Crop producers addressing production problems look to a variety of sources of information, including the public sector—Cooperative Extension and Experiment Stations—and private sector organizations such as consulting firms and firms that contract to buy agricultural products. The quality and accessibility of advice is variable and largely dependent upon access to experienced persons and databases. The databases available are usually in printed format, often highly dispersed, are of doubtful currency, and require interpretation by an experienced, knowledgeable person. Budget constraints in both the public and private sectors make access to experienced persons increasingly difficult or expensive. Recent advances in experience-based programming technology make it possible to develop widely available, user-friendly expert systems that allow farmers to have easy access to expert advice and information on how to best manage their crops.

Our goal is to continue in the direction of developing expert systems for crop management and use the barley expert system as a prototype to develop expert systems for other crops.

The project is funded by the Colorado Institute for Artificial Intelligence. CIAI requires cooperation between the research institution and industry. Our industry partner is the Adolph Coors Co. of Colorado. Coors supplies barley crop management support through 15 area field agronomists who provide advice to Coors’ barley growers. A domain expert is needed for the development of an expert system, and the 15 Coors agronomists served as local domain experts, while Professor Robert Croissant of the Department of Agronomy was the global domain expert. While Coors’ agronomists supplied localized experience-based knowledge, Colorado State crop specialist Croissant supplied the research perspective and resolved conflicts that arose among local experts.

The barley management expert system will provide advice in the areas of fertilizer and water management. The application amount for nitrogen and phosphorus will be recommended by a fertilizer module. Irrigation recommendations including when and how much to irrigate will be given by an irrigation module. Other crop production recommendations may be incorporated in later stages of the program development.

A working program will be deployed next spring as the project reaches its third year. Coors’ agronomists will serve as the initial users and provide feedback on the performance of the program. As Dr. Broner states, “Our goal is to continue in the direction of developing expert systems for crop management and use the barley expert system as a prototype to develop expert systems for other crops.”

(Continued page 21)
The Department of Atmospheric Science is participating in studies on mesoscale observations, analysis, and modeling through the work of four of its faculty members. A summary of latest developments is given below.

The research of Steven A. Rutledge, who joined the faculty of Atmospheric Science in 1988, focuses on the study of mesoscale convective systems (MCSs) both in the middle latitudes and the tropics. MCSs are large precipitation systems—100 to 500 km—which produce much of the warm season precipitation at middle latitudes, and provide an important source of heat energy to the middle latitude and tropical atmosphere. These systems contain both intense thunderstorms which produce heavy rain, and extensive stratiform clouds which produce more widespread, lighter precipitation. The tremendous cloud cover associated with these storms play important roles in the transfer of solar and infrared radiation in the troposphere. Also, MCSs are prolific sources of lightning, capable of producing 5000 or more cloud-to-ground lightning flashes in one hour.

Dr. Rutledge has conducted several observational research programs over the past several years in the midwest United States (Kansas and Oklahoma) and in the vicinity of Darwin, N.T., Australia. These programs use a combination of Doppler radars, instrumented aircraft, lightning detection networks and surface weather stations to study the internal circulations of these storms, precipitation processes in the clouds, and cloud electrification processes leading to the onset of lightning. An observational program is currently being conducted at the Australian field site in Darwin under support from NSF.

Large severe storms that cover several-state areas, such as the storm depicted in the satellite photograph on right, produce up to 70 percent of the warm season rainfall over the central United States. These storms, or MCSs, were the subject of an intensive experiment in May and June 1985 conducted by Colorado State and other scientists involving atmospheric soundings, Doppler radars, and research aircraft centered over Kansas and Oklahoma. Already, several important new discoveries about the structure and behavior of these storms have emerged from analyses of data from this experiment.

This information will hopefully lead to improved predictions of severe storms.

Dr. Richard H. Johnson, principal investigator for this project, states, “One new finding has been the documentation of circulation features within the storms that tend to organize them onto much larger (statewide) scales than those of the individual thunderstorm cells of which they consist.” Another important result has been the identification of processes important to the initiation, development and decay of mesoscale convective systems. This information will hopefully lead to improved predictions of severe storms. Dr. Johnson plans to continue research involving both data analysis and numerical modeling for both the 1985 experiment and a forthcoming, more-encompassing national STORM Program scheduled for the early 1990s.

Under the direction of Drs. W. R. Cotton and R. A. Pielke, an atmospheric model referred to as the Regional Atmospheric Modeling System (RAMS) has been developed. Principal contributions to the development of RAMS from this department include C. J. Tremback and Dr. R. L. Walko, who developed the

(Continued page 2)
several different research projects pertaining to environmental issues currently are underway in Civil Engineering's Geotechnical Engineering Program. A brief overview of two of these projects is given below. The projects are being conducted under the supervision of Dr. Charles Shackelford, assistant professor.

**Leachability of Heavy Metals from Fly Ash and Fly Ash Amended Soils**

The National Science Foundation recently awarded Dr. Shackelford a research grant to study the leachability of heavy metals from fly ash and fly ash amended soils. Fly ash is the finer portion of the residue obtained from the combustion of pulverized coal in boiler units used for generating electricity. About 70 million metric tons of fly ash are produced per year in the United States, but only about 20 percent of the fly ash produced currently is being utilized for productive purposes, e.g., as an additive in Portland cement. The remaining 80 percent is being disposed of in waste containment facilities. This disposal of fly ash represents not only a waste of a potentially useful material but also a significant expense to the electric power industry.

Due to its physical properties, fly ash and soils amended with fly ash are being considered as materials which can be utilized as engineered containment barriers for waste disposal. However, a potential "pitfall" in this utilization of fly ash is the possibility for leaching of heavy metals associated with fly ash into the surrounding environment. Many of these heavy metals are considered to be toxic above certain minimum concentrations.

This disposal of fly ash represents not only a waste of a potentially useful material but also a significant expense to the electric power industry.

Research was begun in September to evaluate the effects of three parameters—flow rate, cation exchange capacity, and permanent fluid characteristics—on the leachability of heavy metals from fly ash liner materials. Laboratory column tests will be conducted on fly ash in various combinations with cement, bentonite, and sand using several flow rates and permanent fluid characteristics. The concentrations and amounts of specific chemical species, e.g., Cd, Zn, Pb, Ca, Mg, Na, K, Cl, etc., being leached from the fly ash mixtures will be monitored to draw conclusions about the effects of the parameters on the leachability of heavy metals. As a result of the research, a more valid assessment of the use of fly ash in waste impoundment facilities will be possible. Such an assessment may have far reaching technical and economical implications, especially for the electric power industry.

**Measurement of Solute Breakthrough Curves Using a Flow-Pump Permeameter**

A second project currently in progress involves the evaluation of the use of the flow pump permeameter to measure solute breakthrough curves. A breakthrough curve represents the temporal variation in the concentration of a solute during transport through a column of soil. The flow-pump permeameter differs from other types of permeameters in that the flow rate is controlled at a constant rate. Flow-pumps have been used primarily in the measurement of the permeability of soils; little work has been done using the flow-pump permeameter to measure contaminant or solute breakthrough curves in soils. The reported advantages of using flow-pumps for permeability testing include relatively short testing times and a more realistic evaluation of the existence, if any, of a threshold hydraulic gradient. The present study represents an attempt to evaluate the use of the flow-pump permeameter to measure solute breakthrough curves for compacted clay soils. The study consists of three stages: (1) development of the permeation and detection equipment; (2) measurement of solute breakthrough curves for simple inorganic salt solutions; and (3) determination of the applicability and/or the limitations of the method. The study currently is in stage two.

(Continued page 21)
APPLYING MICROWAVES TO NON-DESTRUCTIVE TESTING

A variety of techniques involving the use of most conceivable forms of energy have been developed to test products in manufacturing firms. However, concerns for improving productivity and performance, as well as safety considerations, have led industry to investigate the use of nondestructive methods of inspection. At Colorado State, Drs. Satish Udpa, Lalita Udpa and Reza Zoughi have been involved in various methods of nondestructive testing techniques.

Examples of techniques that have been widely used in industry include radiography, as well as electromagnetics and ultrasonic methods of nondestructive testing (NDT). For electrically conducting environments, low frequency electromagnetic techniques have proven successful. For materials such as composites and plastics used in many industries, electromagnetic techniques are not applicable due to the low conductivity associated with these materials.

Dr. Zoughi will be working with microwave NDT techniques, which are suitable for defect detection in such materials and monitoring of their curing process. The ability of microwaves to penetrate dielectric materials, their relatively small wavelengths, increased signal bandwidth, their coherency properties, availability of various inspection probes, and polarization characteristics are properties that can be exploited for nondestructive inspection.

Microwaves have received limited attention in large part due to the fact that, until recently, engineering structures were primarily metallic in nature. Recent advances in the development of materials such as composites and special plastics have altered the picture. The light nature of these materials combined with their exceptional strength and toughness have led to their widespread use in areas ranging from aerospace and surface transportation to utilities.

The inspection of these materials, however, offers considerable challenges. The anisotropic nature and poor conductivity associated with most of these materials limit the usefulness of low frequency electromagnetic methods. Microwave techniques offer significant advantages as a tool for inspecting materials with low conductivity. The large bandwidth associated with microwaves makes for fine resolution measurements. In addition, the wave nature of the microwave phenomena permits application of a wide variety of signal processing methods such as synthetic aperture focusing techniques for imaging. Test parameters such as frequency, polarization, and radiation direction of microwave energy can be exploited, which will ultimately lead to investigating changes in the field patterns in the presence of defects of varying shapes and sizes.

Dr. Zoughi has been involved in microwave NDT research since joining the department in 1987, and has offered a new course in microwave design.

The research group led by Drs. Satish Udpa and Lalita Udpa is actively involved in electromagnetic and ultrasonic methods of nondestructive testing. The group has been focusing its attention on numerical modeling of NDT phenomena as well as techniques for solving the inverse problem. Among accomplishments, the team has played a pioneering role in the development of parametric signal processing techniques for characterizing eddy current signals and the use of neural networks for solving the inverse problem.

Soviet scholar Valery Rudnev, on leave from Kuibyshev Polytechnic Institute, is one of 35 Soviet exchange scholars visiting the United States. Dr. Rudnev will spend eight months in the Department of Electrical Engineering working with Dr. Satish Udpa on problems relating to modeling of diffusion phenomena.
The arrow-pierced figure of San Sebastian is ubiquitous in the Medieval and Renaissance collections of the major art museums of the world. The secular Twentieth Century analog combining both mechanical engineering and veterinary surgery is known as exterior skeletal fixation, the temporary support of a fractured bone using stainless steel pins penetrating the skin and attached to a bridge-like structure outside the body. The purpose of this structure is to enhance bone healing and reduce an animal’s suffering, in sharp contrast to San Sebastian’s plight.

Research is underway at Colorado State to determine the optimal design for the skeletal fixator. Dr. Michael Hsiand, professor of mechanical engineering, and Dr. Erick Egger of the Department of Clinical Sciences, hope that results of their research will accelerate the healing of broken bones even when the injury is severe such as those caused by gunshot or automobile impact. Bone must be loaded in order to remodel and produce a solid juncture. However, during the initial stages of healing, the bone fragments must be held rather rigidly for the blood vessels to resupply the region.

The scientists have found that progressive reduction of the load carrying capacity of the fixator accelerates the healing and remodeling of the bone as the bone carries successively more of the load. Furthermore, it has recently been observed by a group of researchers in England that a few minutes of harmonic load vibration of the healing bone even further facilitates the healing and results in a stronger bond.

Engineers and surgeons at Colorado State are designing fixators using mechanical test machines that control the stress, strain and shear applied to a fixator. They seek a design that can be progressively modified so that its stiffness properties can be changed over a twelve-week healing period. The deformations of the fixators are also measured when placed on injured animals in order to determine the optimal fixture of the fixator in vivo.

The group is also working on a cheaper acrylic model that can be applied quickly by a practicing veterinarian in the clinical environment, reducing the cost incurred by the client.

The purpose of this structure is to enhance bone healing and reduce an animal’s suffering, in sharp contrast to San Sebastian’s plight.

Mechanical design and testing of skeletal fixators can lead to new ways to accelerate bone healing in animals.
and porous media flow" and dedicated service to the American Society of Agricultural Engineers. The Hancor Soil and Water Engineering Award was presented to Dr. Duke at ASAE's annual meeting in Ontario City, Ontario, Canada.

ATMOSPHERIC SCIENCE

A major focus of Dr. Cotton's research is the analysis and numerical simulation of summer thunderstorm systems that are organized on horizontal scales of several hundred kilometers. These thunderstorm systems, or MCSs, are responsible for producing major outbreaks of severe weather events such as flash floods, damaging winds, tornadoes, and hail. At the same time, they are the dominant system contributing to rainfall in the spring and summertime over the Colorado mountains and High Plains.

Drs. Cotton, Rutledge and Johnson are now looking forward to the STORM I field programs to be held in the central United States in 1992 and 1993. These major cooperative field programs offer the opportunity to study MCSs over a much broader range of scales than has hitherto been possible. For example, we can examine an MCS that forms in the Colorado mountains, follow its life cycle and identify its structural characteristics as the storm-system moves eastward over Kansas, Missouri, and on into Illinois or Arkansas. Our challenge will be to simulate the storm systems with RAMS over a similar range of scales!

CIVIL ENGINEERING

Professor Robert L. Schiffman presented the Geotechnical Engineering Distinguished Lecture at Civil Engineering's banquet on Oct. 19. Professor Schiffman's research and professional activities have been concentrated in the areas of computing (software engineering), stresses in earth masses, and consolidation processes. In 1949, he was the first civil engineer in the United States to use modern computers to solve civil engineering problems; he was in charge of the development of the SEPOL subsystem of the ICES system at MIT.
The 1990 Engineering Days will be held April 27-28. Alumni are invited to attend.

College students have historically shown an interest in the world they will inherit, particularly when it comes to issues like clean air and safe habitats. This year's group of engineering students is no exception, as demonstrated by the theme they chose for the November 9, 1989 Engineering Symposium — Engineering Within Global Change. A panel comprised of Robert Woodmansee, Director of the Natural Resource Ecology Lab, Thomas McKee, professor of atmospheric science, and Doug Fox, supervisory research meteorologist of the U.S.D.A. Forest Service, discussed this issue at the 7:30 p.m. symposium. Panel moderator was Dr. Robert Ward, associate dean for undergraduate studies.

The symposium is sponsored each fall semester by Engineering Legislature, which also plans and organizes the annual Engineering Days at Colorado State, held during the spring semester.

The topic of the 1989 Engineering Days (held April 21-22, 1989) was "Engineering: Adapting Technology to the Environment." Engineering Legislature, the student group which coordinates and executes E-Days, selected this theme to reflect their interest and concern with environmental issues which they will face when they graduate and take positions of leadership in industry, government and academia. To enhance their knowledge of environmental concerns, the students invited James Kenney, senior engineer in construction management with CH2M Hill Engineers, to give the keynote address. Mr. Kenney has worked on highways in Colorado and Wyoming and planning for the Two Forks Dam project.

Engineering Days also offers students a chance to show what they have learned at Colorado State, as freshman and senior design projects are readied for viewing by high school teachers, students and their parents. Our Colorado industries enjoy the opportunity to display their latest products, and last year's participants at E-Days could sample soft drinks cooled by a modern commercial ice machine or test their endurance on a computerized exercise bicycle.

Several new events were added last year. Students attending the first E-Days Bash danced to the music of a live band comprised of engineering students. And 325 students involved in the high school Math Engineering Science Achievement Program competed in the egg drop contest, wherein they designed and built a structure of their choice around an uncooked egg, which was then dropped from the Lory Student Center balcony. Winning designs were chosen for the speed at which they traveled and the condition of the egg when it landed on the ground. Contest winners in the velocity category were three women students from Trinidad High School who had constructed their models prior to coming to the university campus. A bridge building contest also attracted a number of contestants who were challenged to construct a bridge from popsicle sticks. Prizes were awarded for the designs which withstood the most pressure.

Officers of the 1989-90 Engineering Legislature who are planning April 1990's E-Days are Tamara Johnson, President; Catherine Nutting, Vice President; Jeff Brown, Secretary; and Linda Li, Treasurer. They invite you to write for more information on how you can participate in this student-sponsored event.

The next Engineering Days will be held April 27-28, 1990. Alumni are invited to attend.

**ENGINEERING INDUSTRY DAY—NEW DATE ANNOUNCED**

The 1990 Engineering Industry Day will be held April 27 in Fort Collins.
Robin E. Herron recently joined the college as professor and Director of the Human Engineering Research Laboratory in the Department of Mechanical Engineering. He has served on the faculties of the University of Illinois at Urbana-Champaign, Baylor College of Medicine, University of Akron and Northeastern Ohio University's College of Medicine. He has also served as college dean at the University of Illinois and Colorado State.

Dr. Herron is a graduate of Queens University, Belfast where he received his B.A., and the University of Illinois where he received his master's and doctorate. He completed a postdoctorate in physiology at the Institute of Occupational Health in Helsinki, Finland. His research interests are in bioengineering.

Douglas C. Hittle has been appointed the new director of Colorado State's Solar Energy Applications Laboratory (SEAL). Founded in 1972 by Dr. George O.G. Lof, a pioneer in solar energy research who now serves as senior adviser at the lab, research projects at SEAL have focused on renewable and non-polluting energy technologies. Past directors of the laboratory have been Dr. Lof and Dr. Susumu Karaki.

Under Dr. Hittle's guidance, the laboratory will be expanding its research focus to include energy conservation, control of energy systems, optimizing building design and operation, and other aspects of building energy use.

Dr. Hittle received his bachelor of science degree in mechanical engineering, master's in environmental engineering, and doctorate in mechanical engineering from the University of Illinois, Urbana-Champaign. Prior to joining the faculty at Colorado State, Dr. Hittle was an associate professor of mechanical engineering at Purdue University. His research interests include solar energy systems, energy conservation, simulation, energy management, and control of air conditioning systems.

David R. Martinez has taken a new full-time position with the College of Engineering as assistant dean for undergraduate studies. As assistant dean, he will have responsibility for directing the Minority Engineering Program and the Counseling and Career Center. His duties will include freshman advising and recruiting, recruitment and retention programs for minorities and women, external relations with junior and senior high schools, and improvement of advisement activities in the college.

Mr. Martinez comes to the college with an excellent background. He has served in the U.S. Navy and has been employed by US West, the Mile High United Way, and Inroads, Inc. He joined Inroads in 1984 where he was Manager of Recruitment and Training. He brings broad contacts with Colorado industry and a familiarity with the Denver area secondary and middle schools to his new assignment.

Mr. Martinez earned a Bachelor of Arts degree in economics from the University of Colorado. He is a board member of the Hispanic Educational Advisory Council for the Denver Public Schools and a board member of the Denver Community Development Corporation.
AWARDS

DISTINGUISHED SERVICE AWARD WINNERS ANNOUNCED

This year two of the five Oliver P. Pennock Distinguished Service Awards presented by Colorado State went to College of Engineering faculty. Vincent Murphy, head of the Department of Agricultural and Chemical Engineering, was cited for his outstanding departmental leadership and extraordinary dedication. The recipient of four teaching awards, Dr. Murphy began Colorado State’s student chapter of the American Institute of Chemical Engineers, which was again this year named an Outstanding Student Chapter.

C. Byron Winn, professor and head of the Department of Mechanical Engineering, was cited for his innovation and leadership within the University and his field. Among Dr. Winn’s accomplishments as department head is the establishment of a faculty mentoring program and restructuring of the undergraduate curriculum. Nominations for the Pennock Awards come from colleagues or students.

DEAN’S COUNCIL ADVISORY BOARD PRESENTS 1989 WINNERS

Alumni, faculty and friends of the college gathered at the annual Engineering Dean’s Council Dinner on Oct. 21 to honor the following members of the Engineering faculty for their outstanding contributions during 1989: Ramchand Oad, agricultural engineering; Duane Stevens, atmospheric science; Vincent Murphy, chemical engineering; James Ruff, civil engineering; V. N. Bringi, electrical engineering; Jack Cermak, engineering science; and Paul Wilbur, mechanical engineering.

The award dinner also gave the college and Dean’s Council Advisory Board an opportunity to recognize the 1989 Dean’s Council Scholarship recipients. This year’s winners were Nayeem Alam (EE), Glenn Criswell (ES), Mark Eaton (ChE), Deborah Cross (ME), Mary Williams (CE), and Bradley Wind (AgE).

The Achievement Awards presentation which concluded the evening’s ceremonies paid tribute to these winners.

DISTINGUISHED SERVICE AWARD—Gerald E. Arnold

During the course of a career spanning 60 years, Gerald Arnold has become a recognized leader in environmental engineering. He began his distinguished career after receiving his bachelor of science from Colorado State in 1926. He has served as a consultant to national and foreign governments on water supply and environmental engineering projects. He has received worldwide recognition for developing innovations in water treatment and laboratory examination of water. Mr. Arnold’s acceptance speech, which received a standing ovation at the Dean’s Council dinner, is reproduced on the following page.

Individual Achievement Award—Chris J. Christopher

Mr. Christopher is general manager of the Graphics Technology Division for Hewlett-Packard. He began his career with Hewlett-Packard in 1968 after earning his bachelor of science in electrical engineering from Colorado State, where he completed his master’s degree in 1974. Mr. Christopher has been involved in many of the successful new products recently introduced by HP. He has played a key role in the development of HP desktop computers and their evolution into engineering workstations with state-of-the-art graphics capabilities.

Public Service Award—Ralph W. Adkins

Ralph Adkins is President of Ralph Adkins & Associates, Inc., a water rights consulting firm in Pueblo, Colorado. He is a Colorado native and a 1943 Colorado State graduate in civil engineering. He spent forty years of his career with CR&I Steel Corp. During the last 18 of those years he directed all water-related matters for the corporation. Mr. Adkins has been active with the Colorado Water Congress and has served on that board.

Corporate Enterprise Achievement Award—Amoco Foundation, Inc., and Amoco Corp.

Amoco Foundation and Amoco Corp. continue to enhance the College of Engineering through generous financial support of people and programs, through active recruitment of graduates, and through the championing of new ideas and technology.

George L. Koonsman

Corporate Service Award—Centennial Engineering, Inc.

Centennial Engineering was established 15 years ago by George Koonsman and Al Menhennett. It has steadily grown to include offices in several states and 175 employees. The company successfully competes for major civil engineering projects around the world. In April, Centennial Engineering received the American Consulting Engineers’ Grand Award for Engineering Excellence. The company continues to embody the spirit and the commitment to quality exemplified by the late George Koonsman.
he acceptance speech of Mr. Gerald E. Arnold, given at the October 21 Dean's Council Dinner in Fort Collins, follows.

Thank you, Dean, and your Council for selecting me for this distinct honor. Frankly, I'm somewhat surprised to be the recipient. First, I'd like to thank Professors House, Fennock, Adams, McDonald, Huckleby and others who were my teachers. They taught me the use of the tools that I acquired right here at CSU, and those tools have enabled me to accomplish the objectives that have been my life's work.

Sixty years of civil engineering all over the world have been an interesting and challenging experience. I was head of the water departments in three of the largest cities in the United States. I have served in various other capacities in engineering throughout my life.

While I was the head of the water department in Philadelphia, I was appointed to the Engineering Manpower Commission of the Engineers Joint Council in New York. The commission makes studies of trends in engineering and the demands for men trained in particular fields. For example, when computers came into general use, there was tremendous demand for electronic engineers. Some of the companies that made the equipment even proselytized faculty members away from the universities to design and construct computers. That was unfortunate in that it depleted the field of training and experience that is needed in order to properly train others.

The crying need today is in environmental engineering. Air and water pollution, industrial wastes, solid waste disposal, ground and soil contamination, the presence of carcinogens in food and water are all major problems. They will demand attention and the work of trained engineers for many years to come.

Engineers can't do it all alone. We will need help in chemistry and biology particularly. The commission makes studies of these trends and recommends to the universities courses to be offered and where the emphasis might be placed. I am happy to have been a member of that commission for five years and its chairman for two years. We recommended to the universities the changes which should be recognized in connection with changing times so that trained people would be ready and prepared to fill those spots where they would be needed.

I have received a good deal of satisfaction from my work with the commission. I have felt that I have been at least partly helpful in training men for the future where they will be needed.

My foreign work was very interesting and challenging. For more than twenty years I worked mostly overseas with developing countries which were badly in need of water and sewer facilities. The institutions which have provided the money for this work in overseas countries were such organizations as the World Bank and USAID, and they selected an engineer to supervise the work that was being done in those countries. They saw to it that the money was expended where it was intended to be used.

I enjoyed my overseas work which was fascinating and, as I say, challenging. The language problem was one of the things we had to face. While they gave me an interpreter in most places, the interpreter was not technically trained, and such things as flow rate controllers and reduced pressure valves were unknown to them; they didn't understand what I was talking about. But we managed to survive, and I just thank God that I have been able to be of assistance to these countries in giving a better way of life to millions of people. These were not all small cities. I worked with various sizes, all the way from designing a filter plant for a city of four million people down to laying out a water system for a little native village in Southeast Asia. It's all been interesting and fascinating, and I am pleased that I've had the opportunity to be of service.

I have received awards and honors on other occasions, but none can compare with this one. This, ladies and gentlemen, is the crowning joy of my life, my glory and happiness. And for that, I thank you, and thank you.
ALUMNI NOTES

Alumni Notes is a compilation of news on alumni activities. If you have information on alumni, or want to tell us about your recent activities, please send in the form below to the Engineering Development Office, Room 107 Engineering Building, Colorado State University, Fort Collins, Colorado 80523.

Garland Laliberte (Ph.D., agricultural engineering, '66) has been appointed dean of the Faculty of Engineering at the University of Manitoba. He is a Fellow of the Agricultural Institute of Canada and the Canadian Society of Agricultural Engineering, and President of the Association of Professional Engineers of Manitoba.

James L. Rasmussen (Ph.D., atmospheric science, '68) was recently appointed as Director, World Weather Watch, World Meteorological Organization, Geneva, Switzerland. Dr. Rasmussen will supervise the standardization and implementation of weather observations throughout the world.

Jerry D. Mahlman (Ph.D., atmospheric science, '67) is the Director of the Geophysical Fluid Dynamics Laboratory of the National Oceanic and Atmospheric Administration located in Princeton, New Jersey. This laboratory is the focal point of NOAA's research into large scale modeling of the atmosphere.

Charles G. Mather (B.S., mechanical engineering, '82) is currently employed by Pyropower Corp. in San Diego, California, as a performance/proposal engineer.

Andrew M. McGuire (B.S., agricultural engineering, '87) is stationed in Guaranda, Ecuador, as a volunteer with the Peace Corps. He is involved in potable water systems and small scale irrigation in rural communities in the mountains of central Ecuador.

OBITUARIES

Philip E. Riddell (B.S., mechanical engineering, '31) on May 8 in Fort Collins.

Charles W. "Bill" Reed (B.S., civil engineering, '55) on July 16 in Aurora, Colorado.

ALUMNI WE WOULD LIKE TO HEAR FROM YOU

Please send us information about your recent activities that you would like to share with your college classmates and other alumni, faculty, and friends of the College of Engineering.

Clip or copy this form, or send a letter to:
Engineering Development Office, Room 107 Engineering Building, Colorado State University, Fort Collins, CO 80523.

Your Name ____________________________

Colorado State Degree(s), Year(s) ____________________________

Current Address ____________________________________________

City ____________________________ State ___________ Zip ____________

Current Employer ____________________________ Job Title ____________________________

Recent Activities ____________________________________________

I would like more information about or copies of:

☐ Engineering Endowment Program
☐ Estates, Wills, Trusts
☐ Scholarships
☐ 1870 Club
☐ Business Challenge Endowment
☐ Other ____________________________
1990 ENGINEERING
ACHIEVEMENT AWARDS

As Engineering begins its second century at Colorado State, the college is seeking nominations for the 1990 Engineering Achievement Awards to be presented at the Dean's Council Dinner in the Fall of 1990.

The Engineering Achievement Awards recognize alumni and friends for their significant professional and personal accomplishments and/or service to the college. The college invites nominations for the six awards. Please send nominations by August 1, 1990 to the Engineering Development Office, 107 Engineering, Colorado State University, Fort Collins, Colorado 80523. The college asks that this nomination form be used, but additional information, including a current vita of the nominee, is encouraged.

The Awards

INDIVIDUAL ACHIEVEMENT AWARD
This award is given to a Colorado State Engineering alumnus/alumna who has been active in the field of engineering for at least five years. This individual has contributed to the general field and has been recognized by the profession and/or trade associations for those contributions.

DISTINGUISHED SERVICE AWARD
This award, the highest alumni honor granted by the college, recognizes exceptional leadership in and dedication to the field of engineering. The recipient has contributed significantly to engineering on both the local and national levels; has possessed an extraordinary commitment to his/her profession; and has been recognized for his/her accomplishments by peers. In addition, through his/her contributions, he/she has enhanced the society in which he/she lives.

PERSONAL SERVICE AWARD
This award recognizes a non-Colorado State University employee who has actively supported the College of Engineering's programs for at least five years. This support must have contributed towards the attainment of the college's goals or the enhancement of its national and international prestige.

PUBLIC SERVICE AWARD
This award recognizes any publicly-elected or appointed official whose activities have furthered the College of Engineering's objectives. The recipient's contributions have had a lasting impact on the college locally, regionally, or nationally, and those contributions have been honored at the state or national level.

CORPORATE ENTERPRISE ACHIEVEMENT AWARD
This award recognizes a company or corporation which has provided outstanding achievements in engineering or engineering research. The recipient has been recognized as a leader in the field of engineering and has enhanced the Colorado State University engineering program's national and international reputation. The company or corporation also must have contributed to the engineering sciences or research with an earnest, coordinated effort on the part of its employees.

GEORGE L. KOONSMAN CORPORATE SERVICE AWARD
This award was inaugurated in 1989 by the Dean's Council Board of Directors in honor of the late George L. Koonsman. It will be awarded to companies who demonstrate outstanding leadership in and exceptional service to the field of engineering. The corporation must emulate Mr. Koonsman's commitment to the attainment of the College of Engineering goals and enhancement of its national and international reputation. Nominees for the Koonsman award will be accepted annually. The award will be given when the Dean's Council Board of Directors determines there is a deserving nominee.

DEVELOPMENT OFFICE WELCOMES NEW ASSISTANT DIRECTOR

Elizabeth (Beth) Weaver has taken the position of Assistant Director of Development in the College of Engineering. A graduate of Colorado State with a B.A. in technical journalism, Beth will work with Development Director Vicki Lebsack on the college's campaigns. Before taking her current position in engineering, Beth served Colorado State as Associate Coordinator of Prospect Research and Management. She is an active member of numerous development boards, including the Colorado Association of Fundraisers.
Nomination Information

Award Category
Nominee's Name
Company/Title
Address
City_________________________State_________Zip________Telephone________

Qualifications: (Please include additional information on attached sheets if necessary.)

1. Career Accomplishments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Professional Associations:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. Personal Affiliations/Accomplishments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Other Comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Nominator's Name

Address

City_________________________State_________Zip________Telephone________
PHOTOGRAPHS
All photographs courtesy of Colorado State Photographic Services with the exception of:
- P. 9 Courtesy National Park Service Air Quality Division Archives
- P. 11 Peter McKinney
- P. 13 Centre for Groundwater Research, University of Waterloo
- P. 16 Phil King
- P. 17 Thomas Rickenbach (lightning) & NOAA-Boulder (satellite image)

Colorado State University is an equal opportunity/affirmative action institution.
© 1990 Colorado State University College of Engineering