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The Center for Energy Studies is a multidisciplinary research center, the central liaison for energy research, education, and public service at The University of Texas at Austin. Dr. John R. Howell is director.

Editor: Jennifer Evans

Railplug developed as sparkplug alternative

The University of Texas at Austin has applied for a patent on a miniaturized railgun that holds promise for doing the job of an engine sparkplug with better fuel efficiency and less pollution. The device is called a railplug.

"It's a radical new concept," said Ronald D. Matthews, an associate professor of mechanical engineering and one of the coinventors. He describes it as an example of technology transfer from the Star Wars space defense effort to the automotive industry.

The railplug is about the same size as a sparkplug, but emits a

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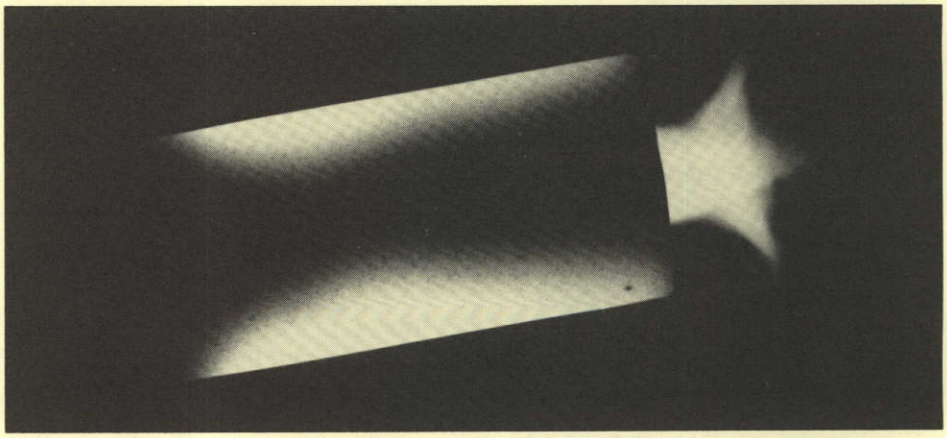
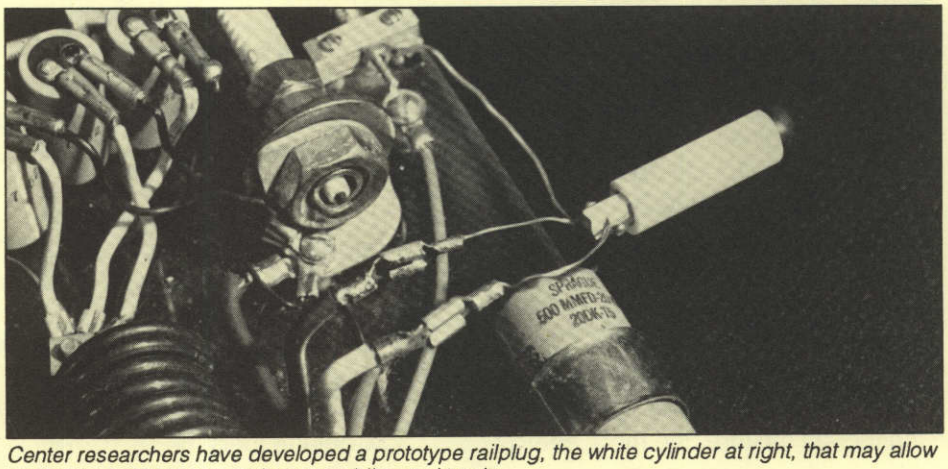


Photographed in the dark, a railplug discharges an intense jet of plasma.



Center researchers have developed a prototype railplug, the white cylinder at right, that may allow fuel savings of 20 percent in automobiles and trucks.

plasma arc that is more intense than a spark. The plasma shoots out the railplug muzzle at great velocity—up to Mach 10. Several railplug prototypes have been built.

A new route to the lean-burn engine. The original notion of the railplug came from Brian Harden, PhD candidate in mechanical engineering. Two years ago he began work on a research project that dealt with railguns and plasma-wall interactions; at the same time he took Dr. Matthews's class on engines, where development of a lean-burn engine was discussed. Mr. Harden put the two ideas together and realized that a railgun-type ignitor might be the key to developing a lean-burn engine, a longstanding automotive design challenge.

Dr. Matthews saw potential in the concept, as did railgun expert William F. Weldon, director of the UT Center for Electromechanics, and Steven P. Nichols, deputy director of the Center for Energy Studies. Together the four inventors turned the idea into a feasible design. Other participants are K. Shen, Cindy Chaffin, Mike Koenig, Dean Schoppe, and Q.-C. Wang, graduate students; X. W. Zhao, visiting scholar from China; and Mark Koeroghlian, research fellow.

"Virtually all engines are limited in their design by the ignition system, in one way or another," Dr. Matthews said. "Most people don't recognize that because the engines seem to work well."

Experts generally think a lean-burn engine could improve fuel economy by 10 to 20 percent, possibly more, and reduce emissions of oxides of nitrogen, carbon monoxide, and unburned hydrocarbons.

Overcoming cold walls. A conventional engine burns 1 kilogram of fuel to roughly 15 kilograms of air. "If you could get down to 26 or 30 kilograms of air, then you could minimize the emissions of all the pollutants and also improve fuel economy—at least in theory," Dr. Matthews said.

A difficulty with igniting a lean mixture is that the more air present in the fuel-air mixture, the more energy needed for ignition. A second difficulty is that the cold walls of the combustion chamber tend to extinguish the flame when it touches or prevent ignition of a flame altogether.

The railplug may be able to overcome both problems because its plasma arc contains inherently more energy. The moving plasma jet, the "bullet" of the tiny railgun, can be aimed toward the center of the chamber, well away from the walls.

The researchers calculate that a railplug in a lean-burn engine will require about 50 times more electric power than a sparkplug. For the device to be feasible, the thermal efficiency gain must be greater than the electric power penalty, Dr. Matthews said.

The lean-burn engine is not the only application being investigated by the group. The railplug may show promise for ignition in

- Conventional gasoline engines, as a way to control knock and achieve better performance with low-octane fuels
- Large stationary engines
- Cold-weather startup of indirect injection diesel engines
- Alcohol-, natural-gas-, and dual-fueled engines
- Jet aircraft engines

Dr. Nichols said the researchers have had more than a dozen discussions with large companies and the invention has been well received. Representatives from Ford, Chrysler, and other companies termed the concept "exciting." A group of industry experts has been formed to advise the UT researchers (see box).

Many of the ideas for applications have come from conversations with people in the automotive industry, Dr. Nichols said. "They've also raised questions about cost, durability, and energy requirements. We share their concern on these topics, but believe that each of these potential problems can be satisfactorily addressed."

The concern about durability arises because intense plasma energy can erode metal. "We think that we can cure the electrode erosion problems just through the inherent design of the railplug and also through proper selection of materials," said Dr. Matthews.

The essential parts of the railplug are a power source, switch, voltage transformers, insulators, and two parallel rails that are 1 to 2 inches long. The latest prototype can discharge its plasma 300 to 2,500 times a minute.

First engine test this summer. An intriguing aspect of the device is that it may be able to alter the plasma intensity, shape, or velocity in response to changes in the engine, such as speed and load.

The researchers have not yet seen how the railplug performs inside an engine. This summer they will begin testing performance in an actual single-cylinder engine, in a project funded by the Advanced Technology Program of the state of Texas.

The group has begun to develop computer models of railplug ignition. Through modeling they hope to discover the best combinations of rail shape, chamber geometry, plasma velocity, and other factors for the applications under study. ■

Railplug advisory group

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Caterpillar, Inc.

Daniel L. Tribble
Champion Spark Plug Company

Thomas W. Asmus
Chrysler Motors Corporation

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Defense Advanced Research Projects Agency

James R. Clarke
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CES Update

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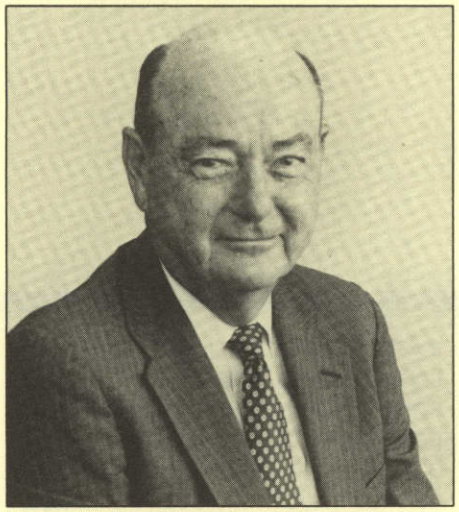


Herbert H. Woodson wins two top national engineering awards.

Herbert H. Woodson, former director of the center, has been named the 1990 Engineer of the Year by the National Society of Professional Engineers. Dr. Woodson is dean of the College of Engineering at UT Austin and is internationally known for his research in electromagnetics and electromechanics. The award is the society's highest honor.

The Institute of Electrical and Electronics Engineers has selected Dr. Woodson as its Outstanding Power Engineering Educator for 1990.

■

John R. Howell, director of the center, has won the 1990 Thermophysics Award of the American Institute of Aeronautics and Astronautics. The institute cited Dr. Howell for his application of the Monte Carlo method to radiation heat transfer.

Dr. Howell has been appointed to head a task force of the American Society of Mechanical Engineers to study ways to increase participation of women and minority members in the engineering profession.

■

Steven P. Nichols, deputy director of the center, has been elected chair of the Council of Space Grant Directors. The council coordinates the activities of the 21 Space Grant Colleges and Consortia of the National Aeronautics and Space Administration.

He was also appointed by the president of the National Society of Professional Engineers to the Board of Governors of the National Institute for Engineering Ethics.

Building Energy Systems

For solar and other renewable energy industries, the forecast has changed from gloom to sunny skies, according to many experts in the field at the **National Solar Energy Conference** held in Austin March 19–22.

Solar photovoltaic (PV) sales increased 37 percent in 1989, and many see solar and the renewables as major strategies to reduce global warming and damage to the environment.

Several speakers suggested to the audience of 700 that the time is right to impose "pollution taxes" on fossil-fuel activities that dirty the water and air.

The federal energy policy of the 1980s was "a policy of benign neglect," according to keynote speaker S. David Freeman, general manager of the Lower Colorado River Authority, a large Texas electric utility. "The Reagan administration came awfully close to declaring war on the sun."

"Will we sit back and watch the Japanese, the Germans, and perhaps the Soviets capture what promises to be a trillion-dollar market?" Mr. Freeman asked. He urged Texas to build a strong high-tech solar industry to replace declining oil and gas.

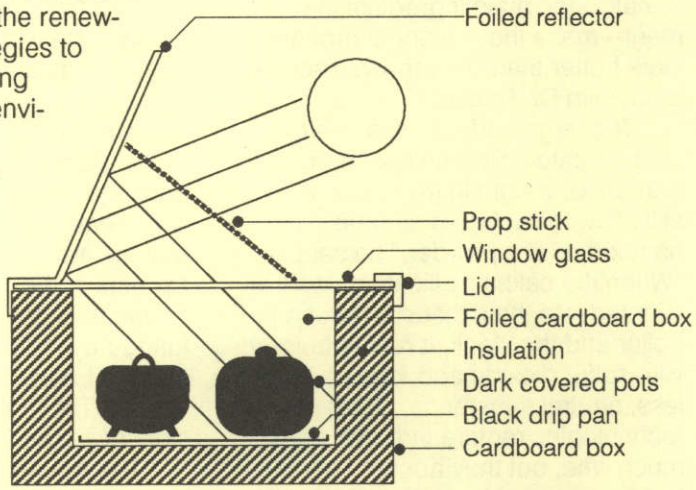
Scott Sklar, executive director of the Solar Energy Industries Association, said that the Bush administration is preparing initiatives to promote export of renewable products and increase funding for R&D on photovoltaics, solar thermal, alternative fuels, and energy-efficient housing.

Federal officials from the Department of Energy and the Environmental Protection Agency said they expect significant budget support for solar, energy efficiency, and renewables in the National Energy Strategy, to be unveiled in December.

US Rep. Jake Pickle (D Austin), a longtime solar advocate, said the federal government should put the same kind of effort into a renewable energy program as it put into the space program.

Among the technological developments discussed at the conference:

- Today's concentrating PV collectors can generate electricity at 12 cents a kilowatt-hour.



A low-tech solar box cooker, exhibited at the solar conference, may be the answer to wood shortages in deforested Third World countries.

- Highly concentrating solar collectors are being explored as a way to break down hazardous wastes.
- A low-tech solar box cooker is being introduced in Third-World countries as a way to cook without electricity or wood. Two billion people have no electricity, and demand for cookfire wood has severely deforested many regions. The solar box cooker is essentially a cardboard crockpot with a foil reflector and tight glass lid to trap heat from the sun. The design is simple enough for a child to make from cardboard, glass, newspa-

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per, aluminum foil, and glue. (For information contact the Solar Box Cookers International Foundation, 1724 Eleventh Street, Sacramento, CA 95814.)

The National Solar Energy Conference was sponsored by the American Solar Energy Society and the Solar Energy Industries Association.

Energy Systems and Economics

Demand for electricity in the United States will continue to pace the GNP in growth over the next ten years, and an electrical energy crisis of some kind is likely during that time, according to the consensus in a **survey of 98 nuclear experts** in industry and government.

The study, conducted by Charles H. Davis as a doctoral project in management and supervised by management professor James A. Fitzsimmons, employed the Delphi technique, a consensus-building survey method. Three rounds of questionnaires were sent to the participants, who could change their responses in light of the group's response on previous rounds.

Industry executives, usually at the vice-president level, were surveyed from companies that design, build, or operate nuclear plants. Government officials included members of the Nuclear Regulatory Commission, chairmen of state regulatory commissions, representatives of state energy commissions, and staff members of energy-related Congressional committees.

The nuclear experts showed near unanimity on some questions and diversity on others:

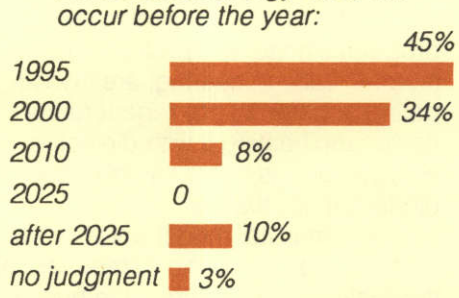
- Between now and the year 2000 electric demand will grow: at the same rate as the GNP (63 percent), slower (12 percent), faster (18 percent), much slower or much faster (0 percent), no judgment (7 percent).
- An electric energy crisis (recurring brownouts, zero reserve margins, etc.) will occur before the year: 1995 (45 percent), 2000 (34 percent), 2010 (8 percent), 2025 (0 percent), after 2025 (10 percent), no judgment (3 percent).
- The most important argument for maintaining a strong nuclear power industry in the United States relates to energy security, defined as gaining independence from foreign oil and gas and ensuring long-term energy self-sufficiency. (90 percent ranked energy security as the first or second highest priority, over economic, social, and technological reasons.)
- Electricity generated by nuclear power will cost less than energy generated by coal by the year: 1990 (1 percent), 1995 (7 percent), 2000 (32 percent), 2025 (26 percent), beyond 2025 (12 percent), never (7 percent), no judgment (15 percent).
- The most economically viable reactor units in the next 25 years will be much smaller than the majority of units recently built. The most promising size is 500 to 600 megawatts (56 percent).
- Light-water reactors (74 percent), as opposed to high-temperature gas-cooled reactors (10 percent), breeders (3 percent), and fusion (0 percent), hold the most promise of commercial viability in the next 25 years (no judgment, 14 percent).
- Standardization of nuclear plants would be beneficial for the industry (97 percent).

On two questions respondents were asked to divide 100 points among several alternatives to indicate relative importance:

- On the nation's R&D effort, nuclear R&D was given the highest priority (36 points, average), followed by cleaner coal (24 points), energy efficiency (22 points), and solar, wind, and fossil energy (18 points).
- On the importance of resolving safety matters confronting the nuclear power industry, the long-term waste disposal issue was given greater priority (47 points) than building safer reactors (34 points) or decommissioning older plants (19 points).

■

Most nuclear experts surveyed predict an electrical energy crisis within 10 years



In a study of the **fuel options for a 415-megawatt power plant** for the Lower Colorado River Authority (LCRA) , center researchers found that, when the costs and economic risks are projected over 30 years rather than 5, Western coal would cost $105 million less than central Texas lignite, although with greater associated risks.

Three UT researchers carried out the study: Martin L. Baughman, associate professor of electrical and computer engineering; Krishan A. Malik, senior research fellow with the center; and Steven P. Nichols, deputy director of the center.

The LCRA board of directors voted in November 1989 to continue to purchase Western coal for its Fayette Power Project Unit No. 3, rather than to complete development of the Cummins Creek lignite mine, scheduled for 1995. LCRA previously had hired Financo, Inc., to compare the costs and risks of fueling the power plant after 1994 with Western coal versus lignite from the Cummins Creek area. Financo's main conclusion was that a Western coal contract would save $43 million over 5 years, compared with the lignite.

The UT researchers concluded that the Financo analysis was fairly sound for the years it dealt with, 1995–1999, but the time period was too short. Dr. Baughman said a 5-year fuel cost projection is not in keeping with standard utility cost analysis because power plants operate for decades. Analyses based on a plant's expected lifetime are the norm. He called the 5-year time horizon "a fundamental methodological error."

The UT researchers performed a 30-year economic simulation (1994–2024) and found that Western coal would cost $105 million (11 percent) less than Cummins Creek lignite over that period.

On the other hand, the price tag

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of either fuel option is subject to risk. The report of the study concluded, "When a 30-year time period is considered, the economic risks associated with Western coal far exceed the risks associated with Cummins Creek lignite."

The group quantified risks with a three-step method that took into account the impact of an individual risk on the cost of operating the plant, as well as the probability of the risk. The researchers projected the economic impact of individual risks on the plant cost, assigned a probability to each impact, and derived from these a curve for each fuel option. The two curves show the probability distribution of the total plant cost. The Western coal curve is significantly wider than the Cummins Creek curve, which indicates more likelihood that the total cost of the plant could run higher or lower than the projected price.

"While the economic risks associated with the Cummins Creek lignite option, except for waste disposal, occur during the early stages of the project, the risks of Western coal are related primarily to the rail freight costs and extend over the life of the project," the study states. "LCRA has a transportation contract to deliver Western coal to the plant site in the near term. . . . [T]here is no assurance that the attractive terms of the existing contract will be extended over the 30-year life of the project."

The research was sponsored by PSE, Inc., which represents lignite owners in the Cummins Creek area. The study was an independent assessment, and the sponsors did not participate in the analysis beyond funding it, Dr. Baughman said.

Process Energetics

The first stage of a **computer model of desiccant systems that are regenerated with dielectric energy** has been developed by process energetics researchers.

Systems designed to reduce the humidity of air usually incorporate a desiccant material, such as pellets of alumina, that absorbs water easily out of humid air. When the desiccant is saturated with water, however, it becomes useless until the water is driven off. Heating the desiccant with hot air is the standard method of regenerating it.

The process energetics researchers, led by Philip S. Schmidt, the program's head and professor of mechanical engineering, are investigating another way to regenerate a desiccant: heating it with dielectric energy such as microwaves and radio-frequency waves.

The computer model will allow the researchers to vary the parameters of the system—for example, the humidity levels of the incoming and outgoing air—to optimize designs and learn if dielectrically based regeneration of desiccants is cost effective. Results from the model indicate that dielectric regeneration is likely to be faster than conventional methods, according to Vince Torres, program manager.

The research project is significant in another way because most of the work has been done by undergraduate students. David Fenton, Martin Kas-tenbaum, and Charles E. Naquin developed this portion of the model as a project in ME 366K, a senior design course in mechanical engineering.

"This type of active involvement of undergraduates is a major priority of our research effort," said Dr. Schmidt.

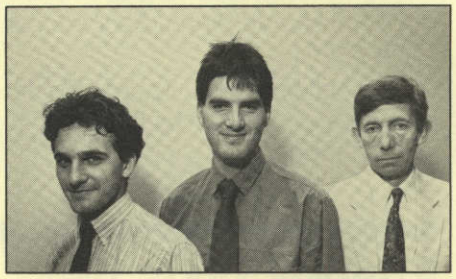
"The students worked in a very real engineering environment, not on a hypothetical problem. The work that they did is of great value to us. They saw how a university research program operates and had an opportunity to be participants in it. It greatly heightened their interest in graduate work."

Mr. Torres said nine undergraduates worked with the program during the spring semester.

■

A report, ***Design and Testing of a 25-kW Infrared Drying System,*** by Stephen R. Brubaker and John R. Howell (R-90-01, 124 p., $25), is available from the Process Energetics Program. Contact Carlene Wooley, Center for Energy Studies, The University of Texas at Austin, Austin, Texas 78758, 512/471-0669.

Separations



Three visiting researchers from Europe arrived this spring to participate in the Separations Research Program: (from right) Michael Biddulph, professor from the University of Nottingham, England (research in distillation); Wolfgang Warmuth, of the Technical University of Aachen, West Germany (ceramic membranes); and Xavier Py, of Rhône-Poulenc, France (extraction).

Technology to reduce drastically the cost of controlling acid rain has been developed by chemical engineers in the center's Separations Research Program and the US Environmental Protection Agency (EPA).

Under a recent agreement with EPA, a process known as Advacate is now available for commercial license from UT Austin. Two patents have been granted on Advacate and others are pending. The process is designed to reduce the sulfur dioxide emitted by coal-fired power plants by 90 percent, said Gary Rochelle, a separations researcher and professor of chemical engineering. He discovered Advacate's basic chemistry in 1985 with Wojciech Jozewicz, then a postdoctoral Fulbright Fellow from Poland.

Dr. Rochelle said that Advacate is less expensive and more effective than comparable systems designed to remove sulfur dioxide, the pollutant primarily responsible for acid rain. The process uses fly ash, a powdery residue left over from burning coal.

In the Advacate process, dust containing fly ash is mixed with lime and hot water to form a calcium silicate slurry. Additional dry dust containing fly ash is added to the slurry, forming a free-flowing powder. This mixture is sprayed through the gas released by the burning coal and absorbs 90 percent or more of the sulfur dioxide.

The powder is removed from the gas and disposed of by regular

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methods. Because it uses existing ductwork and dust collectors, Advacate costs 30 to 50 percent less to install and operate than conventional limestone slurry scrubbing.

The unique properties of calcium silicate—the main ingredient in cement—make the Advacate process work better than conventional scrubbers, said Dr. Rochelle.

"The large surface area of a calcium silicate solid can hold up to 40 percent of weight in free moisture but still allow the substance to be handled as dry powder," he said. "When the calcium silicate mixture is injected into the exhaust between the boiler and the stack, it reacts quickly with sulfur dioxide and forms a harmless, neutral substance. Other new technologies require three times as much lime, but they absorb only 50 to 80 percent of the sulfur dioxide."

Accurex, an EPA contractor, has successfully tested a pilot plant unit at EPA's Air and Energy Engineering Research Laboratory at Research Triangle Park, North Carolina, and a larger, 1-megawatt unit at two power plants.

A 10-megawatt prototype is planned for a Tennessee Valley Authority plant within a year, to be followed by a full-scale 180-megawatt plant, said Mike Maxwell of the EPA Gas Cleaning Technology Branch.

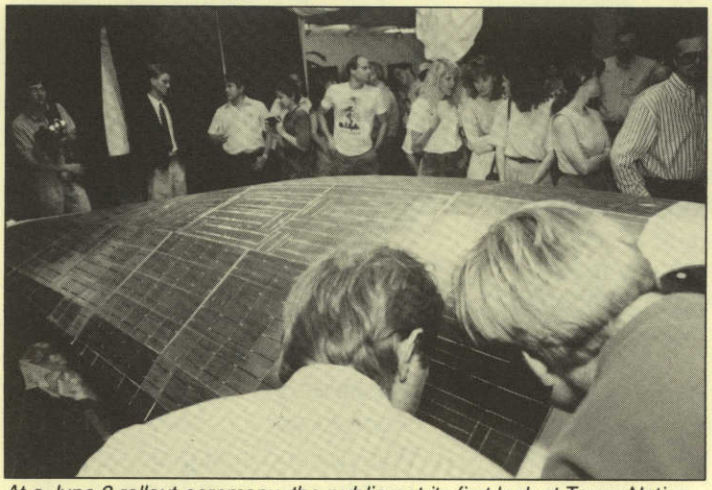
Dr. Rochelle said the Advacate package contains two patents covering silicate preparation and several patents awaiting issue that cover aspects of the chemical process. Advacate's development has been funded by industry, EPA, US Department of Energy, and the 1989 Advanced Technology Program of the state of Texas.

"The Advacate process is very important right now," said Dr. Rochelle. "It is ideally suited for use on existing coal-fired power plants. Two-thirds of these plants have no controls on sulfur dioxide emissions, yet pending acid rain legislation will require them to cut their total emissions from 20 million tons per year to half that." ■

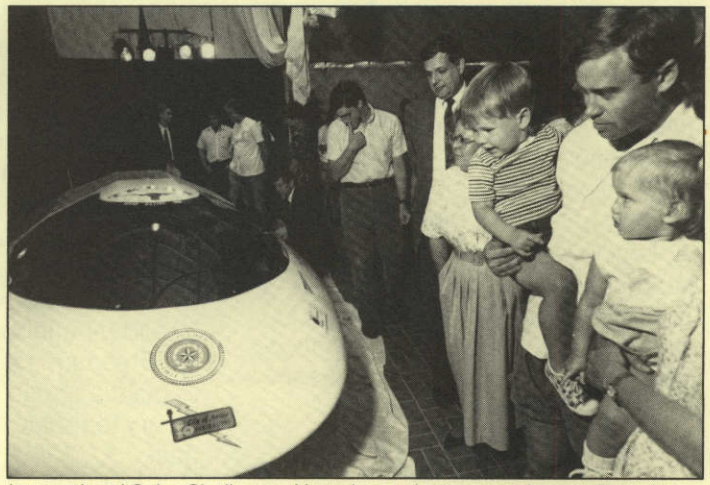
William J. Koros, separations researcher and professor of chemical engineering, has been awarded the General Dynamics Award for Excellence in Engineering Teaching by the UT College of Engineering.

Thermal Analysis

Dale E. Klein, associate dean for research of the UT College of Engineering, has been elected Engineer of the Year by the Travis Chapter of the Texas Society of Professional Engineers. ■



At a June 8 rollout ceremony, the public got its first look at Texas Native Sun, a solar-powered car designed and built by UT Austin students. The UT car will race in the 10-day, 1,800-mile Sunrayce USA, which begins July 9. The first three finishers in the Florida-to-Michigan race will be sponsored by General Motors in a race across Australia in November, the



International Solar Challenge. New donors have recently contributed to the UT photovoltaic car: Mechanical Contractors Association and Sheet Metal Workers Association of Austin, $20,000 each; Bell Helicopter, fabrication support; IBM Austin, two RISC System Series 6000 computers; and UT faculty, about $4,000. More donations are needed.