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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. Herbert H. Woodson is director.

Editor: Jennifer Evans

Microwave Drying Improvements Studied

Center researchers studying microwave energy for drying in industry are investigating how the particle size of a material can affect its drying time.

Drying is a common process in food, chemical, manufacturing, and other industries. Yet the microwave oven, nearly standard equipment for American kitchens today, is not yet widely used for industrial drying. Center researchers see promise in combining microwaves with forced hot air and with air at room temperature.

Drs. Philip S. Schmidt, professor, and Theodore Bergman, assistant professor of mechanical engineering at UT, are leading the center's microwave research. Their goal is to create a base of knowledge about the fundamental characteristics of drying with microwaves so that adequate drying, with minimum degradation and maximum cost effectiveness, can be predicted for a variety of materials.

The research is funded by the Electric Power Research Institute, and other UT participants are mechanical engineering graduate students Jean Accad (now with Thermon Corp.), Thomas Evans, and Nadeem Malik.

In the study of how particle size affects drying, the researchers measured evaporation of moisture contained in beds of water-saturated glass and plastic beads subjected to

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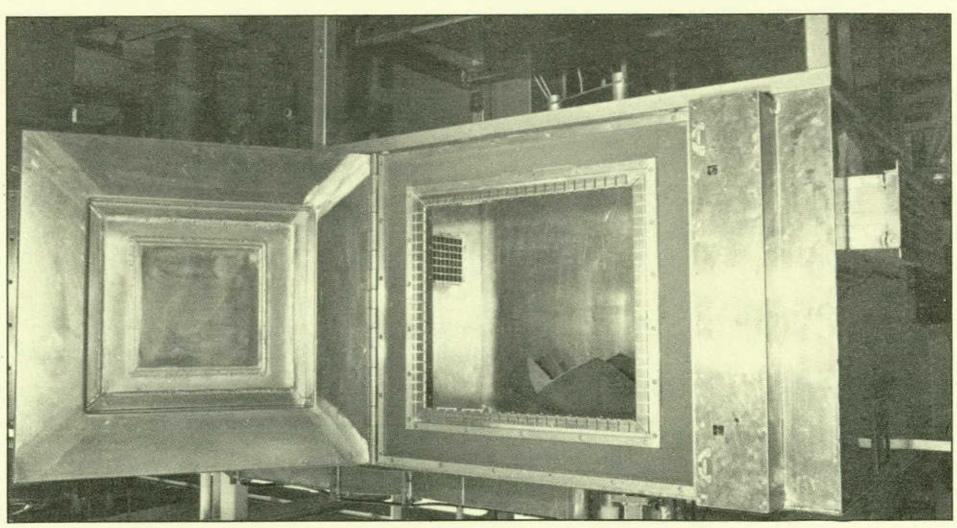


An industrial-size microwave unit will be used in future drying experiments.

varying microwave powers, air flow rates, and air temperatures. The particles ranged in size from 1-micrometer dustlike spheres to pellets 6 millimeters in diameter.

The test materials were dried several ways: with microwaves, with microwaves combined with hot and with cooler air, and with air alone (comparable to a conventional industrial dryer). A 1-kilowatt microwave unit was used. A 6-kilowatt test unit is being fabricated for larger-scale testing to begin in the fall (see photograph).

The results revealed a trend that surprised the researchers. Faster drying occurred with smaller particles. Drs. Schmidt and Bergman said that one possible reason is that, because water has surface tension, the smaller particles allow wicking of moisture to the surface of the bed of material. Where the spaces between the beads are too large, the wicking cannot occur.

The highest drying rates occurred with the microwave/forced-air-flow combinations. The researchers discovered that fairly high drying rates can be achieved even if the forced air is at room temperature.

"This finding can be important because it means you don't always have to spend a lot of money to heat the air," Dr. Schmidt said. "Microwave heating, while expensive, can produce very efficient moisture removal. In some circumstances the net cost of drying can be reduced by the judicious use of microwaves."

Blasting away with microwaves is often not the optimum approach to drying. If overheated or too quickly heated, materials can flake, burst, crumble, dry unevenly, scorch, melt, or chemically degrade.

Microwave dryers used in industrial plants are set to maintain a temperature just under the point at which these sorts of degradation occur. Yet a lower rate of microwave heating and cooler temperatures might sometimes be more suitable in terms of cost and quality, with little loss of time, Dr. Schmidt said.

Microwave heating is more expensive than conventional heating or drying, but it has two characteristics that counterbalance its costliness and sometimes make it the most cost-effective choice. First, microwaves are more efficient for drying because they tend to pinpoint water in a material, heating and driving it to the surface. Second, microwaves can penetrate inside an object and drive out moisture bound within it—what happens when popcorn is popped.

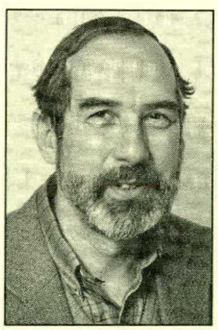
Popcorn is one of the few cases where rupturing a material is desirable. Microwaves can also be used at low power to accelerate the drying of particularly heat-sensitive materials without damaging them, the investigators said.

"The objective of our research program is to establish what combinations of conditions will produce the most efficient and cost-effective drying for any given material," Dr. Bergman said.

(**Note:** The center is developing a **new research program in process energetics**, to be headed by Dr. Schmidt. The program will address how energy in industrial processes can be used most productively. Researchers will carry out technical testing and experimentation, as well as economic and broad strategic studies of industrial productivity. For other process energetics news, see page 3.) ■

CES Update

Office of Director



John R. Howell

Dr. John R. Howell has been named **deputy director** of the Center for Energy Studies. Dr. Howell is a solar and conservation researcher and authority on heat transfer. In the UT Department of Mechanical Engineering, he is E.C.H. Bantel Professor for Professional Practice.

■

Dr. Herbert H. Woodson, director of the center, has been appointed to the Advisory Panel on Magnetic Fusion Research and Development formed by the Office of Technology Assessment of the US Congress.

Electric Power

W. Mack Grady, assistant professor of electrical and computer engineering, has been appointed a 1986–87 visiting scholar by Oak Ridge Associated Universities. As part of the visiting scholar program, he will lecture at several US universities on power systems harmonics and integrating photovoltaics into electric utility systems.

Conservation and Solar Energy

The Third Annual Symposium on **Improving Building Energy Efficiency** in Hot and Humid Climates is scheduled for November 18-19 in Arlington, Texas. The Center for Energy Studies is a cosponsor.

About two dozen topics related to improving the energy efficiency of residential and commercial buildings will be discussed at the symposium.

Technical papers, workshops, a product exhibit, and short courses are to be offered at the symposium. Dr. Jerold Jones, mechanical engineering professor and conservation researcher at the center, will lead a panel in a seminar on the development of ASHRAE Standard 90, a detailed national standard for building energy performance.

The main sponsor of the symposium is Texas A&M University. Other cosponsors include the Gas Research Institute, the Texas Public Utility Commission, and energy agencies from Arkansas, Oklahoma, and Louisiana.

The 1986 symposium will be held in the Arlington Convention Center. About 275 attended the second symposium in the series. Early registration is $125.

For information, contact Dr. Dennis O'Neal, Department of Mechanical Engineering, Texas A&M University, College Station, Texas 77843 (409/845-8039).

■

The Conservation and Solar Energy Program has received $25,000 from the National Association of Homebuilders Research Foundation to study **energy retrofit measures** in apartment buildings in Austin, Texas, and Boston, Massachusetts.

■

A contract to build a $257,000 **dual-air-loop test system** in the center's labs at Balcones Research Center has been awarded to Scientific Development Engineers of Austin, Texas. The system is to be completed by September and will be used for testing air-conditioning and evaporative cooling systems and components.

■

Americans are coming to realize that **passive solar buildings are beautiful**, with dramatic sunspaces, pleasant natural light, and interesting architectural features, J. Douglas Balcomb told audiences in two talks April 15 at The University of Texas at Austin. His visit was cosponsored by the center and the Resource Management Department of the City of Austin.

Dr. Balcomb is scientific advisor to the Solar Energy Section of Los Alamos National Laboratory, currently on leave and serving as a distinguished research fellow at the Solar Energy Research Institute.

He pointed out that twelve years ago five or six passive solar houses existed in the United States. Today there are 200,000.

"Pockets of people are just doing this like mad. Once people see this, it spreads," he said.

"In the last decade we have learned how to design buildings that provide a more pleasant environment in which to live and work and that use much less energy. The strategies used are passive solar heating, natural cooling, and daylighting.

"The remarkable thing is, these tend to be synergistic. They can be done at the same time."

Dr. Balcomb recommended that daylighting be designed into new commercial buildings. Studies on daylighting have shown that people like it better and are more productive in daylit spaces, Balcomb said. Most of the cooling in a commercial building is required by the lights. Daylighting helps reduce the cooling load, as well as reduce or eliminate the energy needed for lighting.

"Although in the last decade we have emphasized energy as the issue, to me the key reason for doing these kinds of things is to enhance the quality of life, to provide a better interior environment, more comfortable, perhaps more visually exciting. We use daylighting more often, simply because it's a nicer quality of light than artificial light. Many of the strategies in this same way are techniques which enhance the livability of the building."


Photo courtesy of Austin Electric Utility Department

J. Douglas Balcomb

Dr. Balcomb said that key research needs related to passive solar energy today are to document the energy performance of window shading devices and of radiant barriers, and to better understand moisture absorption and desorption of buildings.

■

Mechanical engineering professor John R. Howell has written an introductory **thermodynamics textbook** that comes with its own computer disk and contains a different approach to understanding the second law of thermodynamics.

The text, *Fundamentals of Engineering Thermodynamics,* is planned for release in November by McGraw-Hill Book Company. The coauthor is Richard Buckius of the University of Illinois.

The IBM PC-compatible computer disk that comes with the book can be used by students to avoid laborious calculations from property tables.

Dr. Howell said the new explanation of the second law of thermodynamics is easier to grasp than the traditional Carnot engine explanation and is based on observed facts familiar to students.

Process Energetics

A five-day short course, **"Industrial Electrification: Technology and Economics,"** will be taught at The University of Texas at Austin October 6-10 and later in the year at Purdue University in Indiana.

The course will teach participants to evaluate the technical and the economic feasibility of electric-based industrial processes, as compared with rival conventional processes.

The topics to be studied include such processes as electric melting and heating of metals; heating, drying, and curing methods (microwave and radio-frequency heating, infrared and ultraviolet curing); laser and electron-beam materials processing; and heat pumps.

The teachers of the course will be Dr. Philip S. Schmidt, UT professor of mechanical engineering and head of the developing Process Energetics Program at the center; and Dr. Frederick T. Sparrow, professor of industrial engineering and economics at Purdue University.

Dr. Schmidt said the course will be useful for utility representatives in industrial customer service and marketing, process engineers, process managers and engineers, energy researchers, and government policy makers. The UT Center for Energy Studies, UT Continuing Engineering Studies, and the Electric Power Research Institute are sponsoring the short course.

For full information, contact Mike Jackson, Continuing Engineering Studies, ETC 2.138, The University of Texas at Austin, Austin, Texas 78712(512/471-3396).

■

Vince Torres has joined the center as program manager for the developing Process Energetics Program.

Separations Research Program

Membrane separations techniques emerged as the most energy-saving future alternatives to distillation, in a study of separations processes for three industrially important mixtures.

The three mixtures were ethanol from water, oxygen from nitrogen in air, and ethylbenzene from styrene monomer.

In industry today, separation of each of these three mixtures involves distillation as the primary stage. They are energy-intensive processes. The

(Continued on page 8)

UT's Energy-Related Courses and Degree Plans

The University of Texas at Austin offers a wide variety of courses that are energy related—more than 170 undergraduate-level and 200 graduate-level courses. Students interested in majoring in an energy field will find 40 energy-related degrees (or program concentrations) offered at UT. These are also listed below.

Not every course is offered every semester. Those listed here have been offered at least once between spring 1985 and fall 1986.

To learn more about the specific requirements of an undergraduate degree, refer to the catalogue of the college or school in which it is offered ($1 each). For graduate degrees of all kinds, refer to the graduate school catalogue ($2). Catalogues can be purchased from the Registrar, MAI 1, The University of Texas at Austin, Austin, Texas 78712.

Architecture

ARC 340M	Environmental Controls
ARC 340N	Environmental Controls II
ARC 141	Environmental Controls Lab
ARC 355	Alternative Energy Systems Seminar
ARC 355	Application of Energy Methods in Architecture
ARC 355	Manual Methods of Energy Analysis
ARC 380*	Alternative Energy Systems
ARC 380*	Application of Energy Methods in Architecture
ARC 380*	Daylighting
ARC 380*	DEROB Simulation
ARC 380*	Energy-Conserving Design with Mechanical Equipment
ARC 380*	Energy Simulation in Architecture
ARC 380*	Manual Methods of Energy Analysis
ARC 380*	Survey of Environmental Control Systems II
ARC 384M*	Environmental Controls I
CRP 383*	Applied Techniques in Environmental Analysis
CRP 383*	Environmental Policy
CRP 384K*	Natural Resources and Environment Workshop

*Graduate course

Business Administration

BA 279	Problems in Business Administration—Resources
BA 391*	Special Studies in Business Administration: Legal Environment of Business
BA 391*	Special Studies in Business Administration: Resources
BA 691*	Special Studies in Business Administration: Resources
BL 370	Government and Business Topics: Environmental Law
BL 372	Oil and Gas Law
FIN 394*	Industry Analysis
IB 350	International Trade
IB 363	International Commercial Relations and Policies
IB 370	World Resources and International Trade (RES 370)
IB 372	International Business in the Middle East (MES 322K)

IB 395* Business and Politics in the Middle East
IB 395* International Marketing and Middle East Markets
IB 395* Multinational Business Operations
MAN 385* Technology Management—Focus on Oil Field Services Industry
RES 325 Economic Activity and Resource Distribution (GRG 335, IS 320)
RES 326 Texas's Resources and Industries
RES 370 World Resources and International Trade (IB 370)

ENGINEERING

ARE 345 Water, Sanitary, and Electrical Systems in Buildings
CE 341 Environmental Pollution Engineering
CE 342 Water Pollution Control
CE 345 Industrial Hygiene and Toxicology

(Refer to the College of Engineering Catalogue for a full descriptive list of more than 30 civil engineering courses on *air and water pollution control, environmental health engineering, and atmospheric science*.)

CE 358 Introductory Ocean Engineering
CE 364 Design of Pollution Control Systems
CE 369L Air Pollution Engineering
CE 370K Environmental Sampling and Analysis
CE 377K Studies in Civil Engineering: Energy Policy and Ethical Conflict (EE 379K)
CE 377K Studies in Civil Engineering: Hazardous Waste Management
CE 377K Studies in Civil Engineering: Water Resources and Environmental Systems
CE 385J* Hazardous Waste Mangement
CE 385K* Water Quality: Stream and Estuarine Analysis I
CE 388M* Radiological Health
CE 390L* Environmental Analysis
CE 390M* Water Quality Management
CE 396L* Air Pollution Evaluation
CE 396L* Particulate and Gaseous Control
CE 396M* Advanced Topics: Air Pollution Meteorology
CE 397* Advanced Theory of Traffic Flow
CE 397* Environmental Protection in Developing Countries
CE 397* Geotechnical Engineering of Waste Disposal
CE 397* Offshore Structures Seminar
CE 397* Water Pollution Chemistry
CHE 377 Thermodynamics
CHE 354 Unit Operations I: Fluid Flow, Heat, and Mass Transfer
CHE 357 Technology and Its Impact on the Environment
CHE 363 Unit Operations II—Separation Processes
CHE 372 Chemical Reactor Design
CHE 373K Process and Plant Design
CHE 381N* Fluid Flow and Heat Transfer
CHE 388K* Separations Processes
EE 368 Electric Power Transmission and Distribution
EE 369 Power Systems Engineering
EE 379K Power Electronics
EE 379K Topics in Electrical Engineering—Energy Policy and Ethical Conflict (CE 377K)
EE 379K Topics in Electrical Engineering—Environment, Resources, and Technological Risk
EE 379K Topics in Electrical Engineering—Technical Innovationand Bioethics
EE 394J* Applied Solar Energy (ME 394J*)
EE 394J Economic Analysis of Energy Systems (ME 394J*)
EE 394J* Energy Conversion Engineering (ME 394J*)
EE 394J* Power Systems Engineering I
EE 394J* Power Systems Engineering II (ME 394J*)
EE 397K* Advanced Studies in Electrical Engineering—Introduction to Plasma Dynamics

(Refer to the College of Engineering Catalogue for a full descriptive list of more than 30 electrical engineering courses on *power systems engineering, plasma dynamics, and electrical systems*.)

EMR 396* Seminar—Energy and Mineral Resources
ME 320 Applied Thermodynamics
ME 326 Thermodynamics I
ME 328 Thermodynamics II
ME 335K Principles of Comfort Control
ME 337 Nuclear Engineering: Introduction to Nuclear Power Systems

(Refer to the College of Engineering Catalogue for a full descriptive list of more than 15 mechanical engineering courses on *nuclear engineering and fusion engineering*.)

ME 339 Heat Transfer and Rate Processes
ME 360N Intermediate Heat Transfer
ME 361E Nuclear Engineering: Nuclear Reactor Engineering
ME 361F Nuclear Engineering: Introductory Laboratory
ME 361G Nuclear Reactor Operations
ME 361M Thermodynamics of Materials
ME 362K Readings in Engineering (problems of society, technology, and energy)
ME 363L Energy Systems Laboratory
ME 364K Air Conditioning and Refrigeration
ME 374L Design of Thermal Systems
ME 374S Solar Thermal Applications
ME 379K Combustion Engine Processes
ME 381Q* Advanced Thermodynamics
ME 381R* Conduction Heat Transfer
ME 381R* Convection Heat Transfer
ME 381R* Convective Transport
ME 381R* Radiation Heat Transfer
ME 382Q* Design of Thermal and Fluid Systems
ME 382Q* Solar Thermal Energy System Design
ME 382R* Fundamental Combustion Science
ME 387Q* Thermodynamics of Materials
ME 388Q* Nuclear and Neutron Physics
ME 388Q* Nuclear Reactor Theory I
ME 388R* Dynamics of Nuclear Systems
ME 388R* Nuclear Power Engineering
ME 388R* Nuclear Radiation Shielding
ME 389R* Design of Nuclear Systems
ME 394J* Applied Solar Energy (EE 394J*)

(Continued on next page)

*Graduate course

Undergraduate Degrees and Majors

(Programs or Options in Parentheses)

Architectural Engineering (Environmental Systems)
Architectural Engineering and Architecture—a six-year dual program
Architectural Studies
Architecture
Business Administration (Engineering Route to Business, Petroleum Land Management, World Resources and Industries, International Business)
Chemical Engineering (Environmental Improvement, Energy Resources)
Chemistry
Civil Engineering (Environmental Pollution)
Economics
Electrical Engineering (General Electrical Engineering, Power Systems and Energy Conversion)
Engineering Science (Environmental Engineering, Geological Engineering, Nuclear Engineering, Ocean Engineering)
Geography
Geological Sciences
Government
Interdisciplinary Engineering Program: Environmental Quality
Latin American Studies
Mechanical Engineering (Energy and Fluids Systems Engineering, Nuclear Engineering, Petroleum Industry Applications)
Middle Eastern Studies
Petroleum Engineering (Oil and Natural Gas Reservoir Engineering, Oil and Natural Gas Production Engineering, Petroleum Finance and Management)
Physics

ME 394J*	Economic Analysis of Energy Systems (EE 394J*)
ME 394J*	Energy Conversion Engineering (EE 394J*)
ME 394J*	Power Systems Engineering II (EE 394J*)
ME 397*	Current Studies in Gas Radiation
ME 397*	Electric Power and the Environment
ME 397*	Electrothermal Energy Conversion
ME 397K*	Energy and Fluids Systems
ME 397K*	Seminar in Nuclear Engineering
ME 697*	Current Studies in Engineering: Nuclear Engineering Health Physics
PEN 102	Introduction to Petroleum Engineering
PEN 320	Petroleum Exploration and Production (for nonengineering students)
PEN 323	Fluid Flow in Porous Media
PEN 324	Petrophysics and Fluid Laboratory
PEN 326	Thermal and Phase Behavior of Hydrocarbon Reservoir Fluids
PEN 430	Drilling and Well Completions
PEN 331	Fundamentals of Reservoir Engineering
PEN 361	Advanced Reservoir Engineering
PEN 362	Production Technology and Design
PEN 363	Land-Leasing, Royalties, and Conservation
PEN 365	Petroleum Economics and Valuation
PEN 366K	Advanced Production Techniques
PEN 366K	Surface Production Systems
PEN 368	Fundamentals of Well-Logging
PEN 369	Quantitative Well-Log Analysis
PEN 373	Petroleum Engineering Design
PEN 376	Special Problems in Petroleum Engineering
PEN 379	Studies in Petroleum Engineering: Reservoir Evaluation
PEN 280*	Advanced Petroleum Laboratory
PEN 382L*	Numerical Methods in Petroleum Engineering
PEN 383*	Drilling Operation in Abnormal Pressure
PEN 383*	Flow of Complex Mixtures
PEN 383*	Two-Phase Flow in Pipe
PEN 384*	Volume and Phase Relationships in Oil and Gas Mixtures
PEN 386K*	Advanced Fluid Flow in Porous Media
PEN 387*	Secondary Recovery of Petroleum
PEN 387K*	Fundamentals of Enhanced Oil Recovery I
PEN 395*	Rock Mechanics I

(Refer to the College of Engineering Catalogue for a full descriptive list of more than 60 courses on *petroleum engineering*.)

*Graduate course

Law

LAW 341L*	Environmental Law
LAW 263P*	Advanced Oil and Gas
LAW 374N*	Taxation of Natural Resources
LAW 390*	Oil and Gas

Liberal Arts

AMS 315	Environmental History
AMS 315	Environmental Issues in North America
AMS 321	Environmental History
ANS 361	Human Use of the Earth (GRG 346, IS 320)
ANT 391*	Topics in Anthropology: Energy, Power, and Social Progress
ECO 330K	Energy Economics
ECO 350K	Political Economy of International Crisis (EUS 361, IS 320)
ECO 360	Government Regulation of Industry
ECO 380L*	Economic History of the Middle East (MES 381)
ECO 385L*	Advanced Natural Resource and Environmental Economics
ECO 393	The Energy Industries and Energy Policy
EUS 361	Political Economy of International Crisis (ECO 350K, IS 320)
GOV 314	Introduction to the Middle East (MES 301K, OAL 312L)
GOV 337M	Government and Politics of Mexico
GOV 356L	Government and Politics of the Middle East and North Africa

GOV 360N	International Organizations (IS 320)
GOV 365P	Politics of Oil (IS 320, MES 322)
GOV 381L*	Energy Policy
GOV 390L*	Political Systems of the Middle East
GRG 325	Geography of Texas
GRG 328	Geography of the Middle East
GRG 334	Conservation, Resources, and Technology
GRG 335	Economic Activity and Resource Distribution (IS 320, RES 325)
GRG 346	Human Use of the Earth (IS 320, ANS 361)
GRG 351	Man and Nature
GRG 388*	Seminar in Resources and Conservation
IS 320	Economic Activity and Resource Distribution (GRG 335, RES 325)
IS 320	Human Use of the Earth (GRG 346, ANS 361)
IS 320	International Organizations (GOV 360N)
IS 320	Political Economy of International Crisis (ECO 350K, EUS 361)
IS 320	Politics of Oil (GOV 365P, MES 322)
MES 301K	Introduction to the Middle East (GOV 314, OAL 312L)
MES 322	Politics of Oil (IS 320, GOV 365P)
MES 322K	Economic History of the Middle East since 1800
MES 322K	Government and Politics of the Middle East
MES 322K	International Business in the Middle East (IB 372)
MES 324K	Modern Iran
OAL 312L	Introduction to the Middle East (GOV 314, MES 301K)

NATURAL SCIENCES

BIO 301M	Ecology, Evolution, and Society
BIO 304	Environmental and Population Biology
BOT 349	Environmental Pollution
CH 390L*	Advanced Analysis of Electrochemical Methods
CH 397S*	Advanced Analysis of Electrochemistry
GEO 330K	Petroleum Geology—Basin/Trend Analysis
GEO 335	Geology and Resources of Texas
GEO 341	Mineral Resources
GEO 344K	Marine Mining and Minerals
GEO 368	Energy Resources
GEO 368N	Application of Geology to Energy Resources
GEO 379K	Advanced Geology—Oil Exploration and Development
GEO 386L*	Geology of Petroleum
GEO 386M*	Petroleum Exploration Methods
GEO 390M*	Thermodynamics of Geologic Processes
GEO 391*	Economic Geology
GEO 391*	Internship in Environmental Geology
GEO 391J*	Mineral and Energy Resources: Geology, Economics, and Policy
GEO 394*	Oil Exploration and Development
GEO 394*	Research in Energy Resources
MS 440	Limnology and Oceanography (ZOO 440)
MS 354R	Marine Ecosystems
MS 367K	Oceanography: Human Exploration and Exploitation of the Sea
PHY 302K	General Physics—Technical Course: Mechanics, Heat, and Sound
PHY 302L	General Physics—Technical Course: Electricity and Magnetism, Light, Atomic and Nuclear Physics
PHY 303K	Engineering Physics I
PHY 303L	Engineering Physics II
PHY 609A	Elementary Physics for Nontechnical Students: Mechanics, Heat, and Sound
PHY 609B	Elementary Physics for Nontechnical Students: Electricity and Magnetism, Light, Atomic and Nuclear Physics
PHY 316	Electricity and Magnetism
PHY 352K	Classical Electrodynamics
PHY 380L*	Plasma Physics—Introduction
PHY 380M*	Plasma Physics—Stability Theory
PHY 387K*	Electromagnetic Theory
PHY 387L*	Electromagnetic Theory
PHY 391	Seminar in Plasma Physics
PHY 397K*	Nuclear Physics

(Refer to the College of Natural Sciences Catalogue for other courses on *physics, plasma physics, and nuclear physics*.)

PS 304	Introductory Physical Science II: Substances, Heat, Electricity
ZOO 440	Limnology and Oceanography (MS 440)
ZOO 352	Man and the Environment

*Graduate course

PUBLIC AFFAIRS

PA 388K	Seminar on Energy and Minerals ■

GRADUATE DEGREES

(SELECTED PROGRAMS OR OPTIONS IN PARENTHESES)

- Architectural Engineering (Environmental Systems)
- Architecture (Energy Studies in Architecture)
- Business Administration (Management of Technology, Regional Resource Management, Resources)
- Chemical Engineering (Energy Resources, Environmental)
- Chemistry
- Civil Engineering (Environmental Health Engineering, Geotechnical Engineering, Ocean Engineering)
- Economics (Resource and Energy Economics)
- Electrical Engineering (Energy Systems, Plasma and Quantum Electronics)
- Energy and Mineral Resources—a multidisciplinary master of arts degree program
- Geography
- Geology (Economic Geology of Nonmetals and Fluids, Environmental Geology)
- Government
- Latin American Studies
- Law
- Mechanical Engineering (Energy and Fluid Systems, Nuclear Engineering)
- Petroleum Engineering
- Physics (Nuclear Physics, Plasma Physics)
- Public Affairs (Energy, Natural Resources)
- Public Affairs and Business Administration—a joint master's degree

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(Continued from page 3)
study dealt with the processes' energy consumption alone.

The research was conducted by James R. Fair, head of the Separations Research Program; Jimmy L. Humphrey, associate head; and Jose L. Bravo, program manager. It was funded by the US Department of Energy.

Analysis showed that the membrane-type processes in general promise the lowest energy consumption, Mr. Bravo said. Adsorption was seen to be another good candidate for energy efficiency.

Nineteen processes or combinations of processes were studied, each related to:

- ☐ Distillation (including stripping and absorption)
- ☐ Liquid-liquid extraction/stripping (including supercritical extraction)
- ☐ Adsorption
- ☐ Membrane separation of gases
- ☐ Membrane separation of liquids
- ☐ Pervaporation
- ☐ Crystallization

Although new separations processes might eventually replace distillation in certain applications, a more likely direction is combining distillation with one or more new processes, Mr. Bravo said. ■

A study of **fixed-bed adsorption**, a method of separating mixed gases or liquids, has shown that the energy required by the process possibly can be reduced one-half or more.

Fixed-bed adsorption involves passing a mixture through a container filled with an adsorbent, such as activated charcoal. One or more components of the mixture stick—or adsorb—to the charcoal. A gas mask uses this principle to purify air.

To reuse it, the charcoal must first be purged of the adsorbents by means of a hot purge gas, then cooled with a cool gas. The purging step is quite energy-intensive and represents nearly all the energy required by the process.

Dr. James R. Fair, head of the Separations Research Program, said the study demonstrated that the purge step can be much shorter than previously thought. The purge gas can be pushed through the bed with the cool gas, and the heating requirements reduced considerably.

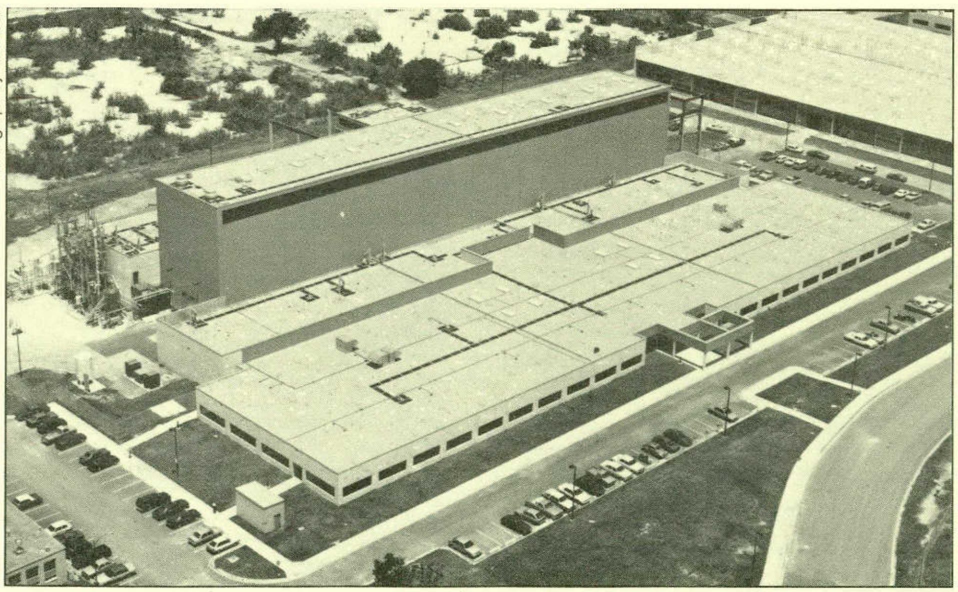
Adsorption is making a comeback as a separations method, Dr. Fair said. Industrial plants often must clean polluted gases and liquids before releasing them to the environment.

"At 1,000 parts per million, most separations methods just don't work. This is where adsorption shines," Dr. Fair said. The fundamentals of the adsorption process are not yet well understood.

The SRP study was carried out by Joan Schork for a dissertation in chemical engineering, and was supervised by Dr. Fair. A propane-nitrogen mixture, an activated-charcoal bed, and nitrogen purge and cool gas were used.

Dr. Schork, now with Alcoa, also developed a mathematical model of the adsorption process that represents the temperature changes and requirements. ■

Photograph by Aerotech



In July the Center for Energy Studies will mark the first anniversary of moving into the new Electromechanics and Energy Building at UT's Balcones Research Center.