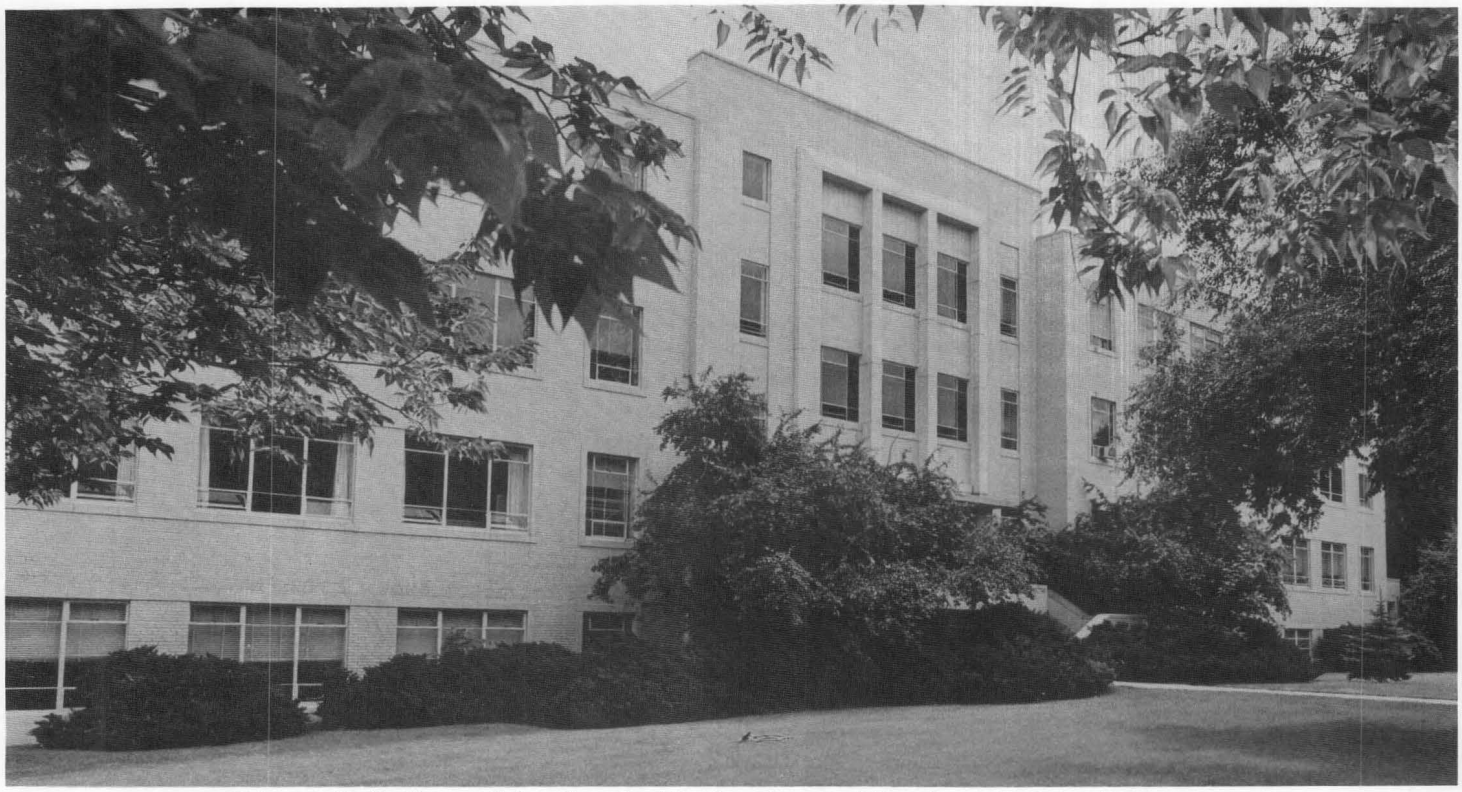


Alderson Hall: Home of the Chemical Engineering and Petroleum Refining Department.

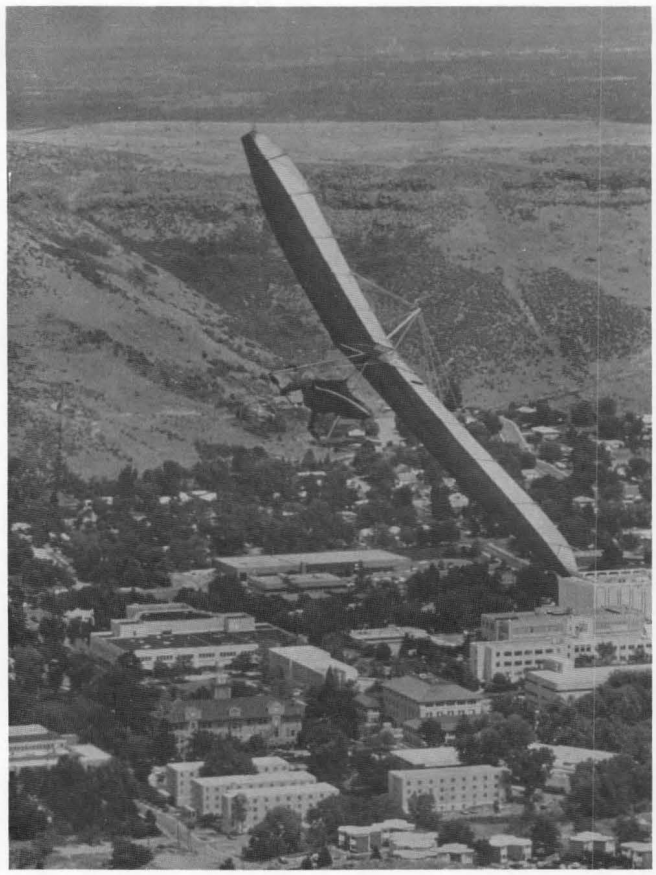
ChE department

COLORADO SCHOOL OF MINES

E. DENDY SLOAN, JR.
Colorado School of Mines
Golden, CO 80401

THE CHEMICAL ENGINEERING and Petroleum Refining Department at the Colorado School of Mines reflects the physical and intellectual community in which it is situated. Our campus is located in Golden, a suburb of Denver, in the eastern foothills of the Rocky Mountains. The town of Golden contains two main institutions: the Colorado School of Mines and the Coors Brewery. A few years ago a pipeline was installed linking the two facilities, but the administration (overriding student protests) insisted that the pipeline contain only steam, to be used for heating purposes.

The prevailing westerly wind over the Rockies undergoes adiabatic cooling as it rises on the western slope, supplying ski areas such as Aspen and Vail with



A hangglider's perspective of the campus, taken from a mountain just outside Golden.

the powder for which our state is famous. When the wind descends on Golden it is both warm and dry, providing a climate with more than 300 sunny days per year. The Rocky Mountains offer a great variety of year-round outdoor activities such as skiing, mountain climbing, hiking, mountain-biking, river-rafting, *etc.* all in spectacular scenery within easy reach of the campus. Perhaps less well-known are the cultural activities in the mountains, such as the Aspen Institute for Humanistic Studies or the various classical and popular music festivals held in the summer. The city of Denver serves as a western cultural center for the nation, offering a diversity of opportunities in the arts, in sports, and in business.

With a population of 14,000, the town of Golden has a relatively small, college-town atmosphere. However, Golden's proximity to several other universities (Denver, Colorado, Metro State, and Colorado State) and facilities such as the Solar Energy Research Institute (SERI) and the National Institute for Standards and Technology (formerly the National Bureau of Standards) creates an intellectual environment normally found only in a much larger metropolitan area.

AN UNUSUAL HISTORY

In 1870, after extensive debate on the relative merits of a school of engineering versus a wagon road for miners, the Colorado legislature decided in favor of the former. The state built the School of Mines to co-exist with a divinity school, called the "University Schools at Golden." The official starting date was listed as 1874, with the initiation of the annual state appropriation. In 1878 the divinity school was destroyed by fire, leaving only the School of Mines planted in the small town twelve miles from the center of Denver.

In 1870, after extensive debate on the relative merits of a school of engineering versus a wagon road for miners, the Colorado legislature decided in favor of the former.

The school has a long history of concern for the quality of student-faculty interactions, beginning with the first meeting between the student body and the Board of Trustees in 1883. Nontraditional students have always been commonplace in the school; the 1880 president's report to the Board of Trustees lists the average age of the students as thirty-one, with many of them coming from the "rough-and-ready" silver mining communities in Colorado. Before the turn of the century, one of the first (1890) football teams of these miners/students (see photograph) humiliated the fuzzy-cheeked fellows from the University of Colorado by a score of 103 to 0!

As the school grew, emphasis shifted from strictly mining. Currently the Colorado School of Mines (like

Binary Choice

This photo is:

a) The CSM state champion football team, circa 1890

- or -

b) the CSM chemical engineering faculty, circa 1990

the schools of mines in London or Paris) graduates only a few mining engineers, yet many of its traditions (*e.g.*, the silver diploma for graduate degrees) are still associated with the mining industry. The school currently has a student body of about 2500 (one-third of which is composed of graduate students) with about 20% women. Entering freshmen are highly qualified, with an average SAT combined score of 1200. An education at CSM is highly prized, as indicated by the fact that both the entering students' SAT score and the undergraduate tuition are among the highest for any state-assisted school in the nation.

The Colorado School of Mines has developed a unique reputation as a world-class institution for education and research in the mineral, energy, and material fields. As a special-purpose university for science and engineering, today's school offers degree programs in twelve technical disciplines which are related to its mission. For one hundred and fifteen years the school has been committed to providing the education needed by future business and research leaders in the industrial areas it serves.

THE DEPARTMENT

The 1912 catalog lists a degree in chemical engineering which grew out of the applied chemistry department, but the degree was abandoned in 1926 because of financial considerations. Then, in 1946 a petroleum refining degree was offered as an option stemming from the petroleum department. It came to be called the Chemical Engineering and Petroleum Refining degree, in direct contrast to most other chemical engineering departments which originated in chemistry departments. James O. Ball was the first department head—a post which he held for fourteen years until James O. Gary joined the school as head of the department in 1960. With Dr. Gary's promotion to Dean of Faculty in 1972, Phillip F. Dickson became head and remained until an untimely illness forced him to step down. Since 1984, Arthur J. Kidnay has ably led the department.

The department is large enough to provide the diversity in research and teaching which is necessary for a sound educational experience, but it is not so large that personal contact between students and faculty is lost. We have consciously determined to keep the ratio of graduate students-to-faculty at about five to one, with about one-fourth of those enrolled studying for their PhD degree. Our undergraduate program is one of the largest in the country and ranks about twelfth in the number of bachelor degrees granted.

The large size of our department makes it possible for students to construct a program best suited to their individual needs. Conversely, the small size of our campus enables a new student to quickly become familiar with the campus and the valuable offerings in other departments. Our department has eight full-time faculty members, all actively engaged in teaching and research, and two research faculty. The research interests of the faculty are listed in Table 1.

TABLE 1
Faculty Research Interests

R.M. Baldwin • *DSc, Colorado School of Mines*
Fuel Science • Coal Liquefaction

A.L. Bunge • *PhD, University of California, Berkeley*
Membrane Transport and Separations • Mass Transfer in Porous Media • Ion Exchange and Adsorption Chromatography

J.H. Gary • *PhD, University of Florida*
Petroleum Refinery Processing • Heavy Oil Processing • Thermal Cracking • Visbreaking • Solvent Extraction

J.O. Golden • *PhD, Iowa State University*
Phase Change Phenomena • Solvent Extraction • Processing of Polymers • Fluid Mechanics

M.S. Graboski • *PhD, Pennsylvania State (Research Faculty)*
Fuels Development • Emissions • Alternate Fuels (Coal, Biomass, Heavy Crude)

A.J. Kidnay • *DSc, Colorado School of Mines*
Thermodynamic Properties of Gases and Liquids • Vapor-Liquid Equilibria • Cryogenic Engineering

R.L. Miller • *PhD, Colorado School of Mines*
Liquefaction Coprocessing of Coal and Heavy Oil • Particulate Removal • Multiphase Fluid Mechanics • Educational Methods

T.B. Reed • *PhD, University of Minnesota (Research Faculty)*
Biomass Conversion by Combustion and Gasification • Methanol Production from Wood and Municipal Waste • Diesel Fuels from Cooking Oils • Alternative Fuels

M.S. Selim • *PhD, Iowa State University*
Heat and Mass Transfer at Moving Boundaries • Sedimentation and Diffusion of Colloidal Suspensions • Heat Effects in Gas Absorption with Chemical Reaction • Entrance Region Flow and Heat Transfer • Surface Phenomena

E.D. Sloan • *PhD, Clemson University*
Natural Gas Hydrates • Thermodynamic and Transport Properties of Fluids • Adsorption • Educational Methods

V.F. Yesavage • *PhD, University of Michigan*
Thermodynamics of Polar-Associating Fluids • Properties of Coal Derived Liquids • Equations-of-State for Highly Nonideal Systems • Flow Calorimetry • Surface Phenomena • Treatment of Mixed Wastes • Photochemical Wastewater Treatment

The challenges facing the chemical engineering community have changed considerably. Easily exploited resources and reserves of the past are now largely gone, and technologies appropriate thirty years ago are no longer economically feasible or environmentally acceptable. A committee report, "Frontiers in Chemical Engineering: Research Needs and Opportunities," sponsored by the National Research Council, identified eight high-priority areas of national need in chemical engineering. At CSM we have active research in five of those eight areas: (1) liquid fuels (shale, coal, biomass) for the future; (2) responsible management of hazardous substances; (3) surface and interfacial engineering; (4) advanced computational methods and process control; (5) *in-situ* processing of resources.

In addition, we continue to maintain active programs in all the traditional areas of chemical engineering, such as applied thermodynamics, kinetics, catalysis, and heat and mass transfer. Interdisciplinary research is taking place in fields as diverse as materials science, hazardous waste treatment, and transport across human skin. Table 2 lists some of the research projects in our department.

Most graduate research is carried out in the department's modern and well-equipped laboratories which occupy one-half of the third and fourth floors of Alderson Hall. In 1991 a new wing of Alderson Hall will be constructed which will effectively double the available research space. Graduate students are normally assigned office space separate from research laboratories. Some graduate research is done in conjunction with local industrial and government research laboratories, such as the National Institute for Standards and Technology, the Solar Energy Research Institute, Coors, and IBM. Our goal is to maintain strength in areas critical to existing industries while creating research programs in areas vital to new and emerging technologies.

TABLE 2
Typical Major Research Areas

Center for High Altitude Fuels and Engine Research • *The department is establishing a new research laboratory, dedicated to research on fuels and emissions from internal combustion engines. This lab will contain both stationary gasoline and diesel research engines with sophisticated real-time analytical monitoring capabilities for both engine performance and emissions data. The primary focus of the laboratory will be research on the effect of fuels on emissions for conventional and novel fuels. The laboratory is scheduled for dedication during the spring of 1990 and will be the only facility of its type in the US that is capable of measuring and correlating fuels properties with engine performance and emissions at high altitude.*

Applied Thermodynamics • *CSM is known internationally for research in this area. Thermophysical properties research is included along with phase equilibria of nonideal systems, heat of mixing, and flow calorimetry. Recent work has incorporated supercritical fluid technology, equation-of-state development, advanced computational thermodynamics, and a program to evaluate the impact of thermodynamic property research on the natural gas industry.*

Natural Gas Hydrates • *Very large deposits of low-molecular weight hydrocarbons are present around the world in solid hydrated form,. Our studies in hydrate thermodynamics, physical properties, and processing are aimed at both recovery and prevention in various portions of the gas production and processing industry. Our laboratory is the largest in the nation in this area and includes an interdisciplinary effort with several other departments, namely chemistry and geochemistry, geology, physics, and petroleum engineering.*

In-Place Remediation of Contaminated Soils • *Of the options for cleaning contaminated soils, methods which do not require soil excavation prior to treatment offer obvious advantages. The objective of this program is to develop a comprehensive research effort studying in-place methods for remediation in zones above the water table. Present projects include soil flushing with chemically enhanced aqueous solutions, enhanced evaporation by forced aeration, and bioremediation. Centered in chemical engineering, this multidisciplinary program involves faculty from chemistry and geochemistry, geological engineering, civil engineering, environmental science, and petroleum engineering.*

Coal Liquefaction • *A number of fundamental and applied studies in coal liquefaction science and engineering are in progress, aimed at coal reactivity correlation and low-severity liquefaction processes. The reactivity research investigates the relationship between coal chemical structure and the rate and extent of conversion to liquids by direct hydroliquefaction. The low-severity program incorporates reactivity enhancement by mild chemical pretreatment, catalysis by basic nitrogen compounds, and low severity coprocessing studies.*

Further Research Areas • *Other innovative research is being carried out in such areas as:*
Biomass Conversion • Catalytic Hydroprocessing of Lignin • Deactivation of Zeolite-Based Isomerization Catalysis • Development of Novel HDO and Naphtha Isomerization Catalysts • Emulsion Liquid Membrane Studies • Extraction of Brewery Products with Supercritical Fluids • Fuels Testing Center for Pollution Control • Mineral Extraction with Supercritical Water • Moving Boundary Problems • Pedagogical Methods of Integration of Humanities in Engineering • Sedimentation Theory • Suspension Rheology • Solute Transport Across Human Skin • Surface and Interfacial Flows • Photochemical Wastewater Treatment

FACULTY AS PEOPLE

The research interests listed in Table 2 invigorate our faculty's activities. However, members of the faculty are vital people in other ways as well. They are professors in the fullest meaning of the word—their intellectual activity and availability extends beyond the time and space boundaries of the classroom/laboratory.

On the wall of **Bob Baldwin**'s office there is a certificate of musical accomplishment from Iowa State—implying that there was a difficult career choice during his student days. Bob teaches in the school's Honors Humanities program and has won several teaching excellence awards. Last year he served as Associate Dean for Undergraduate Studies. When he can manage time away from the Mines campus and the Golden area, Bob is an inveterate globetrotter.

The fact that **Annette Bunge** is the best athlete in the department does damage to our "Rambo" image. Annette coaches the school's mens/women Alpine and Nordic ski teams and participates in all training events with the team. Last year when the team ran a two-mile training run, she had to wait over 1.5 minutes for the second-place finisher. She is an avid outdoorswoman and participates in rock climbing, river-rafting, hiking, crosscountry racing, and diving. She is the recipient of the Dow Outstanding Young Faculty Award from the American Society for Engineering Education (ASEE).

Jim Gary is perhaps our best known faculty member because of his long academic tenure and his classic book in the field of petroleum refining. He came to the school in 1960 and served as Department Head and as Vice President for Academic Affairs and Dean of Faculty (each for about a decade) before resuming an active career in teaching classes and industrial short courses in petroleum processing throughout the world. As the department's only septuagenarian ($\pm 2.9\%$) and one of its most active computer users, he frequently teaches his junior colleagues the newest

in computer hard/software. Jim has received the George R. Brown Medal of Achievement from the school and is a Fellow of both AIChE and AAAS.

John Golden returns to the department after having been led astray into academic administration for the past fifteen years. He has served the School of Mines as Director of Research Development, Dean of Graduate Studies and Research, and Vice President for Academic Affairs and Dean of Faculty. For the 1990-91 academic year he will take a well-deserved administrative leave to relearn some chemical engineering that he forgot during his years of academic administrative combat service.

Mike Graboski returns to the school as research professor after managing his own business in biomass gasification for three years. Mike continues those personal interests he began as a graduate student at Penn

An Ore Cart race on Engineer's Day (the traditional "Spring craziness day" on campus).

State, where he was president of Trout Unlimited. His current hobbies include cross-country skiing, hiking, hunting, and fishing.

Art Kidnay is the department's fearless leader, ranking weightlifter, and intrepid long-distance runner. His colleagues appreciate his magnanimous attitude as well as his limitless capacity for new interests—such as biofeedback tapes to improve running. Art is a Fellow of the AIChE and has won the school's outstanding teaching award.

Ron Miller is the youngest, and by far the most irreverent, faculty member. Students closely identify with Ron—some claiming him as a good friend even after he has taught them! Along with Ron's technical research, he has recently begun pedagogical research to integrate humanities into the initial chemical engineering course. Ron has won school-wide awards for teaching excellence at the University of Wyoming and at the School of Mines.

Tom Reed is a research professor who came to us in 1986 after fifteen years at MIT and nine years at the Solar Energy Research Institute. His initial technical interests were in crystallography and material/energy science, but for the last seventeen years his interests have been in alternative fuels such as methanol and biomass. He has recently started a private company to convert waste cooking oils to diesel fuels.

Sami Selim, the department's mathematical wizard, has a graduate degree in mathematics as well as three degrees in chemical engineering. He specializes in making difficult analytical problems dissolve into thin air, while exhibiting an international flavor of kindness. Sami serves as both the department's opera aficionado and its culinary Epicurean. He has been presented with school-wide teaching excellence awards at three universities, including CSM.

Recently, the only trace of **Dendy Sloan** has been his voice on an answering machine in his office. He was sequestered in the school library until he emerged with the manuscript for *Clathrate Hydrates of Natural Gases*, published in the winter of 1990. His hobbies include attempts at music on the banjo and guitar. Dendy balances a two-career family with his wife, who is an attorney. He is the fifth departmental faculty to be the recipient of a school-wide teaching award.

Vic Yesavage is a displaced New Yorker who rapidly took to the great outdoors. He enjoys family-oriented activities such as camping trips to national parks in the west. Within the department he enjoys the role of graduate advisor to students. In recent years he has become a student of Eastern European history, and he follows the recent developments in that part of the world with great interest.

The faculty feel a collegiality for each other and join in parties, cross-country ski trips, and campouts. These events are filled with appropriate amounts of good cheer, exercise, and comraderie to subsequently remind us of our mortality. While we each maintain independence of thought, our faculty is small enough (and friendly enough) to arrive at a consensus on most issues of departmental concern.

Another outgrowth of this collegiality is a cooperative spirit in which most faculty members have engaged in joint research projects. Cooperation between faculty members is but one indication that our department research activities are continuing to evolve. The intellectual abilities of the faculty, along with fresh input from graduate students, are recognized as the best resources of the department. These resources will carry us into new adventures and new ideas in the coming years. □