OKCHE

SCHOOL OF CHEMICAL ENGINEERING AND MATERIALS SCIENCE THE UNIVERSITY OF OKLAHOMA

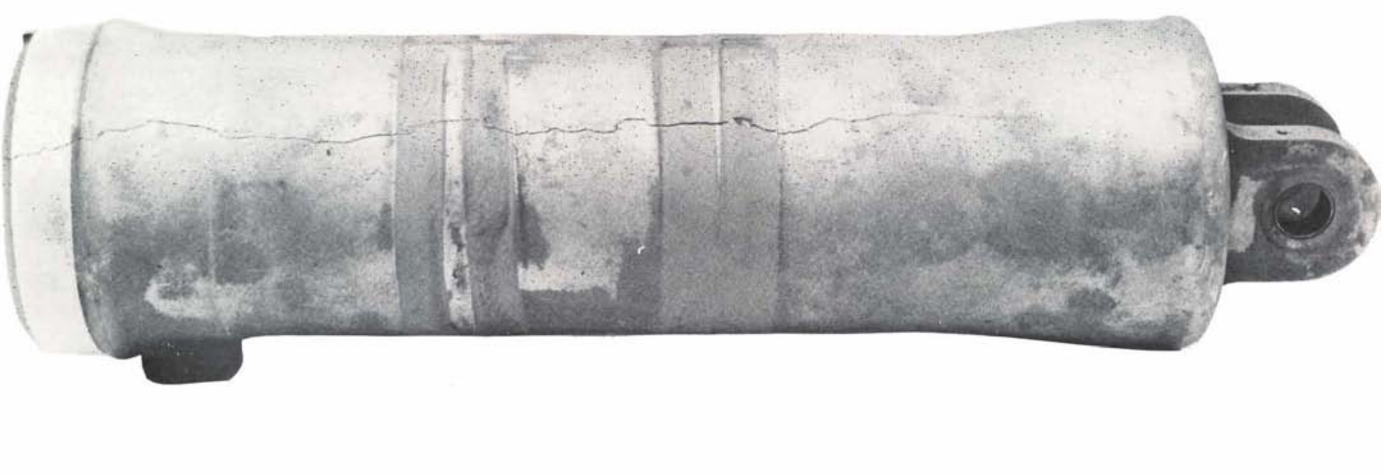
FAILURE ANALYSIS:

OU's Metallurgical Engineers Help the Military

(see related story on page 2)

spring 1979

"Failure of the main landing gear cylinder was determined to be the result of fatigue. Multiple fatigue cracking apparently was initiated through a lap of foreign material lodged into the cylinder wall during forging. The cracks traveled through the cylinder wall under the repeated loadings that were experienced during routine service."



CONTENTS

Winter 1979

Metallurgy and Failure Analysis: an expanding fortune

Graduate student Bill Coleman attempts to determine if a broken drilling mud gear carries an improper gear tooth pitch. Coleman has been involved with failure analysis for three years and is responsible for the preparation of this article for OkChe.

There exists a myth among many engineers in the Southwest that metallurgists spend a typical day amidst huge blast furnaces and rail cars carrying ingots of frozen metal, or perhaps supervising the pouring of heats of iron castings. However, during the last decade, the role of the metallurgist has become steadily more significant to the industrial community and to the average citizen as well. Dwindling supplies of metals that many of us take for granted — such as iron, copper, chromium, and aluminum — have generated many new research fields. Across the country, materials scientists strive to develop alloys to meet the challenges of a changing world.

Meanwhile, smaller teams of metallurgical engineers, dwelling perhaps in the shadows of these innovative crews of researchers, function in an equally valuable service. Instead of forging into the future, many spend their time trying to answer such "mundane" questions as "Why did that gear tooth shear?" or "What caused the crack along the cylinder wall?" or perhaps, "Which design favors the reduction of stresses in the weld zone?" Regardless of the problem, an answer has to be found to these important questions.

As industry migrates more heavily into this section of the country, the need for qualified metallurgical engineers becomes greater, and it appears inevitable that these requirements will continually increase. To accommodate industry, the metallurgical engineering department has sprouted from CEMS and has begun to prosper. As a matter of fact, the number of students in metallurgy has nearly quadrupled in the last two years. After all, the *MS* in CEMS stands for "materials science," and that for the most part means metallurgy.

The underlying reason for the significant growth of interest in metallurgy may well be what is commonly referred to as the "Tinker Project." To gain a better understanding of what that is, one should visit the basement floors of Carson Engineering Center. Scattered about are turbine blades, landing gear cylinders, high pressure tubing, gear trains, and starter assembly components. The most interesting feature about these and other parts being studied is that they all have two things in common: (1) Each was removed from a military aircraft, and (2) most significantly, each failed in service.

Failures of aircraft components . . . Those words ring an unpleasant bell for most Americans as they recall the tragedies that have occurred in recent months in the nation's airways. Although not on such a grand scale, a team of faculty, graduate, and

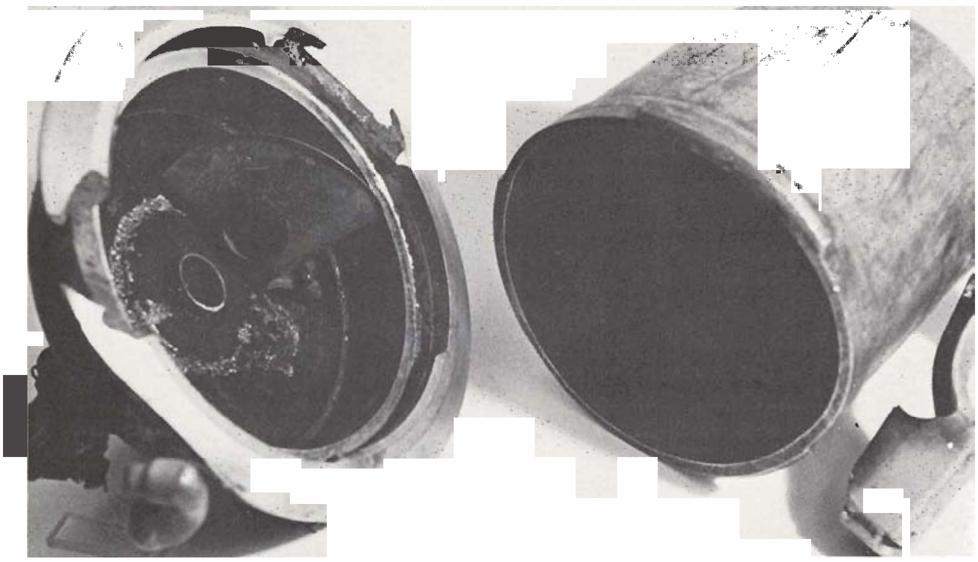


Fig. 1 Chamber assembly of a cartridge starter which failed during jet engine ignition.


Fig. 1a Typical transgranular stress corrosion crack discovered in the chamber assembly. Gray oxide within the crack indicates exposure to high temperatures subsequent to crack formation.

undergraduate students at OU have combined their efforts for the past 16 months in analyzing aircraft failures for the United States Air Force. Instead of DC-10s and smaller commercial aircraft, the A7-D, F-111, B-52, and refueling tankers receive most of their time and concern. Under a contract from the Oklahoma City Air Logistics Center at Tinker Field, the group has studied problems ranging from corrosion and fatigue to mechanical failures and design deficiencies of actual aircraft components.

The project is directed by metallurgical engineering professors Raymond D. Daniels and Robert J. Block, and has been immensely successful since its inception in September 1978. Bill Coleman, a PhD student from Tulsa, supervises the majority of the analyses which are conducted by a number of individuals. Each of the students involved has been assigned the various tasks required for a proper analysis to be performed. E.W. Brothers, Mark Hollrah, Phil Perkins, Sheila Stuckey, Chen-Hsun Hsu, Bob Hoff, and Jeff Bell are among the students assisting in the examinations .

The various assignments are ideally suited to those students who have elected to spend from ten to twenty hours a week applying classroom knowledge to "real" situations. The experience is invaluable, as the students will attest, simply because they are forced to explore all possible avenues leading to a particular failure. Their work may include extensive microstructural examination, hardness measurements, macrophotography, scanning electron microscopy, chemical analysis, and others. Most important, though, is the combination of theory, basic engineering, and the examination of evidence — all essential for a suitable reconstruction of the failure to be achieved.

Some of the most interesting analyses performed thus far have involved stress corrosion cracking in starter chambers (Figures 1 and 1a), fatigue of main landing gear cylinders (Figures 2 and 2a), and fractured gear teeth (Figure 3). Occasionally, the group is asked to certify the condition of various engine or structural components supplied by any of hundreds of vendors used by the military. Case-depth measurement, plating thickness, and verification of various metal heat treatments are among the many tasks performed.

Several students have enjoyed failure analysis enough that they have decided to remain in the metallurgical engineering program as graduate students. While interviewing for employment with a major aircraft manufacturer, one of the students was informed that his interest and experience in failure analysis would virtually guarantee him a well-paying position upon completion of an advanced degree.

Apparently the reports which the investigating teams have produced have been of such admirable quality that the contract value was increased, and extended for another year. In fact, the project has spawned such a great interest that students from other engineering fields have filtered into CEMS and begun to participate by enrolling in a perennially favorite course for metallurgists, "Material Selection and Failure Analysis." Taught by Professor Block, students have solved some of the aircraft failures in addition to other, more common industrial failures (see cover Figure 4).

Fig. 2 Scanning electron micrograph depicting character of fatigue striations detected in the cylinder wall.

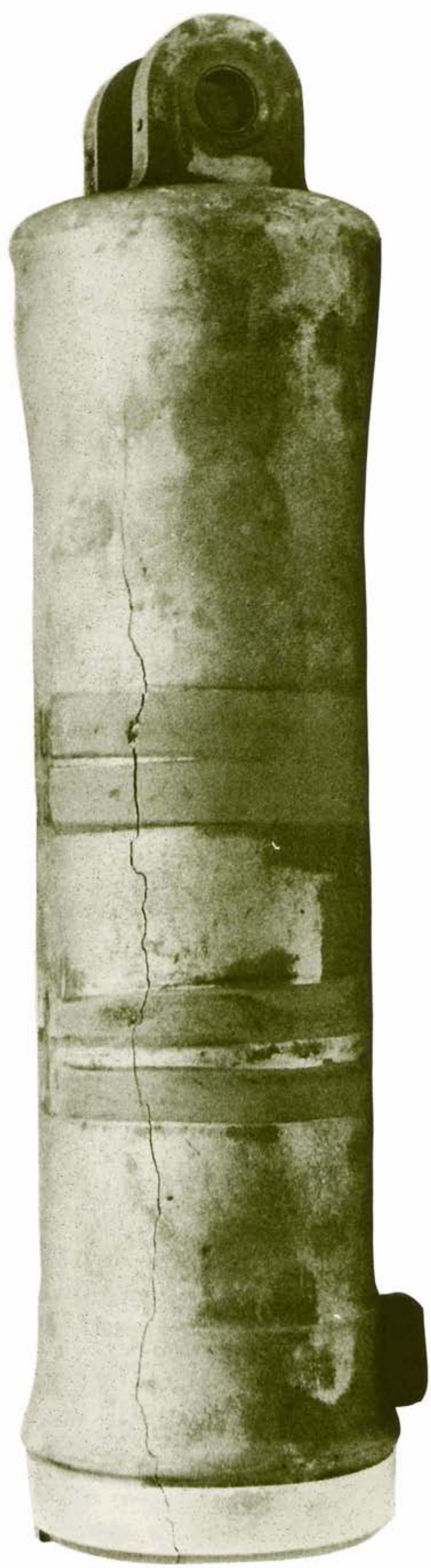


Fig. 2a Overall view of cracked main landing gear cylinder forged from Alumimum 2024.

The most significant attribute of the "Tinker Project" is that it has given metallurgical engineering students a head start in their careers. Gaining great insight toward standard industrial practices while utilizing an opportunity to learn the many aspects of failure analysis, prospective engineers are benefitting notably from metallurgy as an applied science. Remarkably few students in other universities across the continent can boast of similar accomplishments — they simply haven't had this chance.

Current Research in Properties of Tin-Lead and Antimonal Solder Alloys

The availability and expense of various metals, in particular tin, have generated a major study undertaken by three metallurgical engineering graduate students during the past year and a half. The program has included three phases of study, two of which have been completed, comparing a newly developed antimonial solder alloy with the traditional tin-lead alloy commonly employed by the manufacturers of electronics. Industry has sought a replacement for portions of the tin content in tin-based soft solders for a number of years, with limited success. The addition of antimonv with a corresponding reduction in tin spawned the initial phase of the research conducted by Bill Coleman. He studied the primary reactions that occur during soldering, when each alloy is applied to copper and various copper alloy substrates. E.W. Brothers, a senior metallurgical engineer with Western Electric in Oklahoma City and a PhD candidate, followed with a thorough treatise on the interfacial phenomena that occur during wetting of the solder alloys onto copper alloys and gold-plated surfaces.

continued

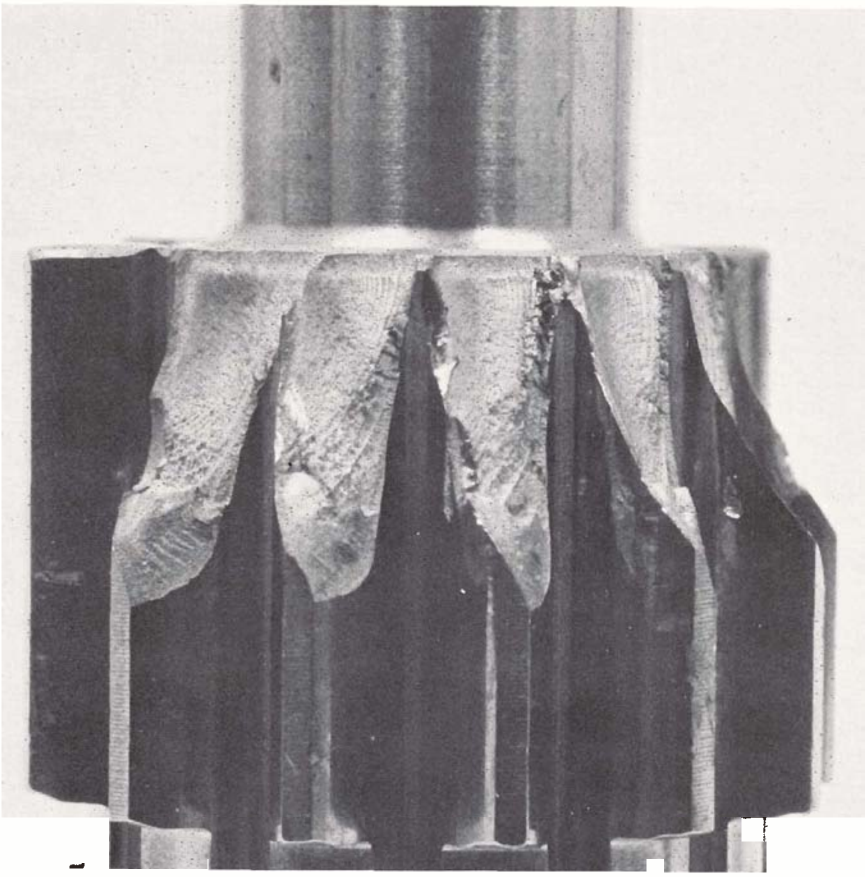


Fig. 3 Engine starter gear teeth which failed because of misalignment. The steps across the fractured metal surface are fatigue striations.

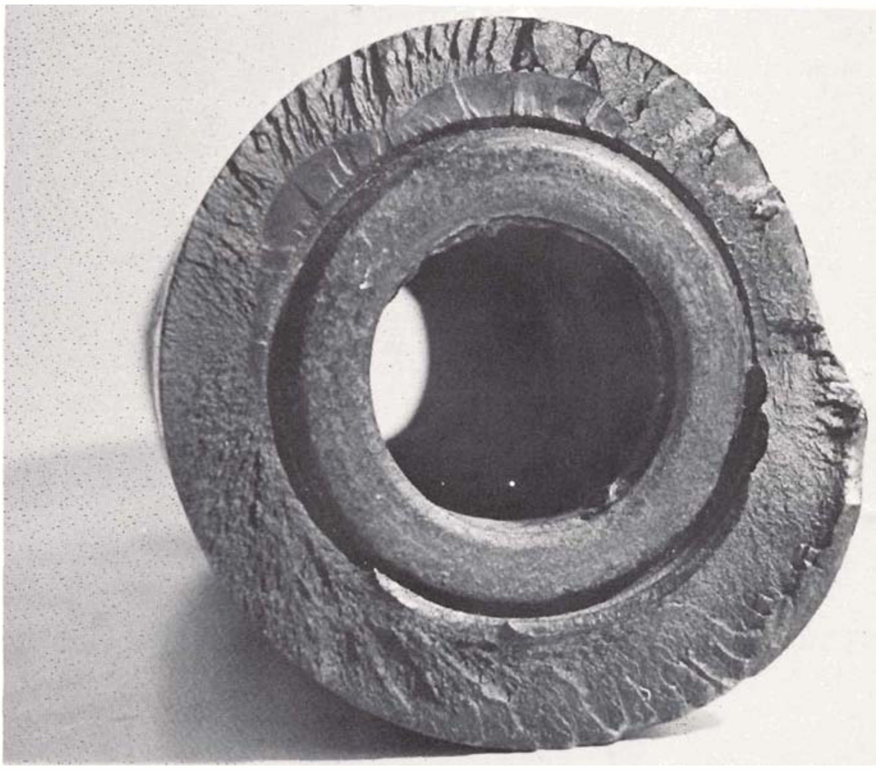


Fig. 4 Drill collar fracture surface exposed following failure by fatigue.

The second phase of the study was recently completed by Rita R. Edwards (a master's candidate also with Western Electric). Ms. Edwards studied the solderability characteristics of the antimonial and tin-lead solders based on wetting rates and wetting times derived from meniscograph and dissolution rate experiments.

The final stages of the work should provide a correlation between the metallurgical bonds produced by the various reactions and the results of mechanical tests (creep, shear, and peel strengths). When completed, the combined efforts of these students should offer valuable knowledge of the metallurgy of soft soldering to the electronics community. Coleman, Brothers, Ms. Edwards, and Professor Block will all present the results of their efforts at the annual meeting of the Metallurgical Society of A.I.M.E., to be held in Las Vegas in late February 1980. The group has also accepted an invitation to submit papers at a conference in Anaheim, California, sponsored by the electronics industry during the same week.

Current Research in Metallurgy

The failure-analysis projects have also resulted in extensive research efforts by several other students. Chen-Hsun Hsu, a master's candidate from Taiwan, recently completed a study involving the precipitation kinetics of a nickel-based super alloy (Mar-M 200). The study was created following the detection of numerous fractures in first-stage turbine blades cast and directionally solidified from the complex nickel alloy.

Sheila Stuckey and Mark Hollrah are currently in the first stage of developing a solderable coating for instrument glass. The aircraft industry is seeking a means of soldering instrument glass to a metal frame, which is then fused to the cockpit instrument panel. The difficulty arises because an air-tight and fatigue-resistant bond must be formed during the operation.

Engergy Economics of Blast Furnace Operations

As alternate energy sources and maximizing current supplies of energy become increasingly important, new methods for harnessing what would otherwise by wasted energy are currently being studied.

Mohammed Elmarghani, a graduate student from Libya, has utilized thermochemical data, thermodynamic constraints of stack chemistry, and operational parameters of normal furnace practice to formulate energy-balance equations for a blast furnace. Using these equations, mathematical models were developed to predict net energy savings when regenerative stoves are replaced with direct-fired heaters as the blast heating source. The results are then extended to include the possibility of producing steel directly within the blast furnace with direct-fired heaters.

Metallurgy — The Years Ahead

Since early history, metals have supplied the world with items too numerous to detail. But now a changing society and the availability of metals dictate that we develop new materials. The engineer may be limited in his or her innovation because new alloys and other materials which suit the needs of a particular design have not been developed. With a little more encouragement and the infinite ambition that has made CEMS grow, the metallurgists who walk our halls now and in the months and years to come will take their place in the advancement of technology. Each individual is important. Whether it be related to failure analysis, solder alloys, metals with memories, or the creation of a heat resistant superalloy, the metallurgists of CEMS will be heard from in this changing frontier.

Winner Take All — Engineering Open House 1979

The 1979 College of Engineering Open House was held Friday and Saturday of Dad's Day weekend, October 26 and 27, with the most prestigious awards going to the technical societies consisting entirely of CEMS students. The top prizes were won by the student chapter of the American Society for Metals (ASM), which captured first and second places in the exhibit category.

Metallurgical engineering students displayed numerous failure-analysis projects and demonstrated the usefulness of the most advanced metallurgical optical equipment. The group secured the second-place slot with perhaps the most fascinating exhibit in the entire Open House, entitled "Shape Memory Effects in Metals." Audiences were captivated by a nickel-titanium alloy which displayed a remarkable ability to recover a predetermined shape when subjected to certain temperatures.

CEMS students also carried away first and third places in the Rube Goldberg contest. First place went to students Mark Southard and Phil Winters, while third place went to ASM.

To all who participated in Open House, congratulations for a job well done!

Meet the CEMS Faculty

The University of Oklahoma is proud of its CEMS faculty, with the diversified educational and professional experience that each member has to contribute. Here we present background information for all of the 1979-80 CEMS faculty members.

Professors Kenneth Starling, Lloyd Lee, Sam Sofer, John Radovich, and Carl Locke

Arthur Wm. Aldag, Jr., Professor

B.S., 1963 — University of Illinois
M.S., 1965 — Stanford University
Ph.D., 1967 — Stanford University

Visiting Assistant Professor, 1968-69, University of Minnesota, Chemical Engineering Department.

Chemical Engineering: catalysis and adsorption at solid surfaces and coupled mass transfer-kinetic effects. Auger spectroscopy and the interaction of molecules with clean metal surfaces.

Married to Phyllis; three children: Laura 17, Lynda 14, and Jim 11. Enjoys music and jogging early in the morning.

Robert J. Block, Professor

B.S., 1956 — Massachusetts Institute of Technology
M.S., 1958 — Columbia University
Ph.D., 1963 — University of Illinois

Metallurgical Engineering: physical metallurgy, effects of surface coatings on plasticity, dislocation arrangements in metals, analysis of metal failures.

Married to Nancy; three children: Debbie, Jennifer, and Jake. Loves to hunt, fish, and snow ski.

Alfred Clark, Professor

B.S., 1930 — Purdue University
M.S., 1932 — Michigan State University
Ph.D., 1935 — University of Illinois

Research Chemist, 1935-36, North American Rayon Corporation.
Research Chemist, 1936-43, Battelle Memorial Institute.
Head, Catalysis Research, 1943-44, Publicker Commercial Alcohol Company.
Senior Chemist, Section Chief, Branch Manager and Senior Scientist-Catalysis, 1944-71, Phillips Petroleum Company, Research and Development Department.

Chemical Engineering: catalysis, chemisorption, kinetics and reaction mechanisms.

Raymond D. Daniels, Professor

B.S., 1950 — Case Western Reserve University
M.S., 1953 — Case Western Reserve University
Ph.D., 1958 — Case Western Reserve University

Physicist, 1949, 1950-51, National Bureau of Standards.
Research Engineer, 1954-55, Linde Company.
National Science Foundation Fellow, 1968-69, University of Neuchatel, Switzerland.

Metallurgical Engineering: physical metallurgy, gases in metals, corrosion, fracture.

Married, with one daughter Pamela, age 22. Member of OU faculty for 21 years.

Lloyd L. Lee, Assistant Professor

B.S., 1963 — National Taiwan University
M.S., 1966 — University of Nebraska
Ph.D., 1971 — Northwestern University

Research Engineer, 1970-71, DuPont Chemical Co., Richmond, Va.
Researcher, 1972, University of Paris.
Visiting Associate Professor, 1972-74 National Central University, Taiwan.
Manager, Engineering Service Division, 1973-75 Tashing Chemical Fiber Company, Taiwan.
Visiting Assistant Professor, 1975-76, Cleveland State University.

Chemical Engineering: thermodynamics, molecular transport theory, statistical mechanics, structure of liquids , Monte Carlo and molecular dynamics studies, conformal solution theory, properties of natural gas, polar fluids, fuel cells and molten salts, surface adsorption, turbulent flow, polymer processing technology: spinning, extrusions, coating.

Member of the CEMS 4-Mile Relay Team. Also loves to ski, scuba dive, and skate.

David S. Lieberman, Professor

A.B., 1948 — Cornell University
M.A., 1950 — Columbia University
Ph.D, 1954 — Columbia University

Professors Arthur Aldag, David Lieberman, Robert Wills, and Robert Block

Assistant Professor, Associate Professor, Professor, Physical Metallurgy, 1954-78, University of Illinois.
Liaison Scientist for Metallurgy, U.S. Office of Naval Research, London, England, July 1961 — August 1963.
Visiting Professor of Materials Science, Technion, The Israel Institute of Technology, Haifa, and Visiting Lecturer, The University of Negev, Beersheba, Israel — winter, spring 1971.
Fulbright Hays Lecturer-Visiting Professor, Technology and Materials Science, Hebrew University, Jerusalem, Sept. 1972 — July 1973, on leave from University of Illinois.
Sigma Xi National Lecturer, 1977-78, 1978-79.

Metallurgical Engineering: physical metallurgy, phase transformations in solids, thermoelastic martensites, "shape memory effects" and applications; self-diffusion and point defects in intermetallic compounds; science and public policy, world mineral and fuel resources, the technology/society interface.

Has two children: one living in Geneva, Switzerland, and the other a junior at Boston Univeristy. Hobbies are sculpting and listening to classical music.

Carl E. Locke, Associate Professor

B.S., 1958 — University of Texas (Austin)
M.S., 1960 — University of Texas (Austin)
Ph.D., 1972 — University of Texas (Austin)

Associate Research Engineer, Sales Engineer and Manager, 1959-65, Continental Oil Company.
Production Manager, 1965-66, R.L. Stone Company.
Program Manager, Thermal Instruments;
Manager, Product Service Center;
Engineer/Scientist and Acting Manager, Chemistry Section, 1966-71, Tracor, Inc.
Visiting Assistant Professor, 1972, University of Texas.
Carbon Black Corrosion Research, Summer 1974, Phillips Petroleum Company.

Chemical Engineering: correlation of polymer molecular structure with thermal and mechanical properties, compatibility of polyblends, graft copolymers, corrosion of steel in concrete, anodic polarization behavior, thermal analysis.

Married and has two children. Hobbies are camping and gardening; a member of the CEMS 4-Mile Relay Team.

John M. Radovich, Assistant Professor

B.S., 1970 — University of Notre Dame
M.S., 1971 — Stanford University
D.S.c., 1976 — Washington University (St. Louis)

Process Engineer, Sun Petroleum Products Co., Marcus Hook, Pa., June 1971-September 1973.

Chemical Engineering: membrane separations for biological mixtures, convective mass transfer of macromolecules, blood processing, conversion of biomass to fuels.

blood processing, conversion of biomass to fuels.

Married and has three children. Member of CEMS 4-Mile Relay Team; also loves to play volleyball, read history and science fiction, and raise girls.

Cedomir M. Sliepcevich, George Lynn Cross Research Professor

B.S., 1941 — University of Michigan
M.S., 1942 — University of Michigan
Ph.D., 1948 — University of Michigan

Assistant Professor and Associate Professor, 1948-55, University of Michigan.

Chemical Engineering: thermodynamics, reaction kinetics and catalysis, high-pressure design, cryogenics, flame dynamics, desalination, hydrometallurgy, viscoelasticity.

Married; guardian for 9-year-old Justin. Favorite pastime is watching Justin participate in sports.

continued

Professors Raymond Daniels, Mark Townsend, and Cedomir Sliepcevich

Samir S. Sofer, Associate Professor and Director

B.S., 1969 — University of Utah
M.S., 1971 — Texas A & M University
Ph.D., 1973 — University of Texas (Austin)

Process Design Engineer, 1969-72, Celanese Chemical Company.
Postdoctoral Research Associate, 1972-73, University of Texas (Austin).
Research Associate, 1974, Clayton Foundation Biochemical Institute.

Chemical Engineering: process design, reaction kinetics, insolubilized enzyme technology, computer simulation of multicomponent processes, biomass conversion to fuels, separation of blood components, detoxification, hepatic assist devices.

Member of CEMS 4-Mile Relay Team; hobbies are tennis and engineering.

Kenneth E. Starling, George Lynn Cross Research Professor

B.S., 1958 — Texas A & I University
M.S., 1960 — Illinois Institute of Technology
Ph.D., 1962 — Illinois Institute of Technology

Research Engineer, 1962-63, Institute of Gas Technology.
Postdoctoral, 1963-64, Rice University Welch Foundation.
Senior Research Engineer, 1964-66, Esso Production Research Company.
Visiting Professor, 1972-73, University of Leuven, Belgium.

Chemical Engineering: equation of state development and prediction of thermodynamic and phase behavior, equilibrium and nonequilibrium molecular theory fluids, correlation of transport properties, process simulation, low temperature difference cycles, geothermal, ocean thermal, solar and waste heat energy conversion.

Married and has three children: Suzanne 18, Scott 17, and Stephen 15. Member of CEMS 4-Mile Relay Team; hobbies are carpentry and auto mechanics.

Indispensable to the smooth functioning of the CEMS department are its support staff: Yolanda Valdez (secretary), Debi DeVilliers (secretary), K. Hudson (research design technologist), Margaret Williford (secretary), and Terry Johnson (secretary).

F. Mark Townsend, David Ross Boyd Professor

B.S., 1948 — University of Oklahoma
M.S., 1951 — University of Oklahoma
Ph.D., 1955 — University of Oklahoma

Chemical Engineering: recovery of sulfur from hydrogen sulfide, desalination of brackish waters by ion exchange, heat transfer in fluidized bed reactors.

Married to Naomi; two grown sons, Mark and Gary. Hobbies are gardening and innovating chemical processes and equipment.

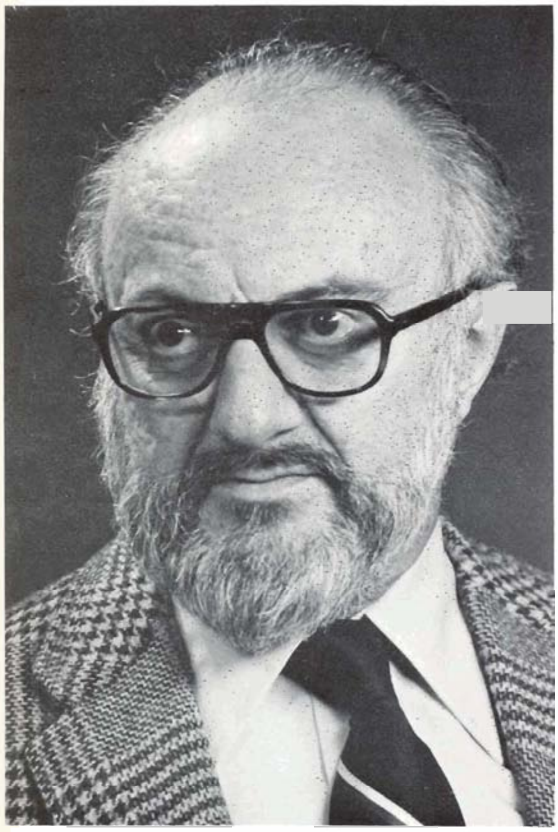
Robert A. Wills, Visiting Assistant Professor

B.S., 1976 — University of Oklahoma
M.S., 1977 — University of Oklahoma
Ph.D., 1978 — University of Oklahoma

Chemical Engineering: enzyme technology, artificial organ research, computer simulation of body detoxification.

Married to Sally. One child, Jennifer, is 4 years old. Plays the guitar, slow pitch softball, and armchair football.

Featuring Dr. Leiberman . . . New to OU



Dr. David Lieberman

David S. Lieberman, Professor of Chemical Engineering and Materials Science, and Research Fellow in the Science and Public Policy Program has joined the University of Oklahoma faculty this fall. In addition, he has continued to honor invitations as a Sigma Xi National Lecturer by speaking to the Iowa State University chapter of Sigma Xi in Ames at their opening meeting on October 25.

Sigma Xi chooses as lecturers a group of outstanding scientists who are available for speaking engagements to discuss "particularly lively areas of current research in a manner appropriate for interdisciplinary audiences." Arrangements are especially helpful for smaller colleges and chapters in allowing them to bring in people they normally would not or could not attract to their campuses.

Lieberman was designated a National Lecturer for 1977-78 and 1978-79. His lecture titles are (1) "Our Material Civilization: From Affluence to Effluence," which stems from his teaching and research interests in world fuel and mineral resources: (2) "Of Memories, Metals, and Motors," an outgrowth of a quarter century of research on martenistic phase transformations, particularly the extraordinary "shape memory phenomena" and applications exhibited by thermoelastic martensites; and (3) "Are We Doing the Right Thing or Just Doing the Thing Right?" — a critical analysis of engineering education for the technology/society interface, and suggestions for its improvement.

During the last two years, Lieberman has presented lectures at the initiation meetings at Carnegie-Mellon University, Pittsburgh, PA; at the University of Tennessee at Martin; at the Armco Research Center, Fermi National Accelerater Lab, and Wheaton College Sigma Xi Club, Wheaton, IL; at West Georgia College, Carrollton; and at the University of Oklahoma under the auspices of the Department of Chemical Engineering and Materials Science and the Science and Public Policy Program.

An Interview with "Dr. Bob"

"Dr. Bob" Wills is a Visiting Assistant Professor in the CEMS department at OU. He has been in that position since he graduated from OU in December, 1978. Although born in St. Paul Minnesota, he considers himself an Oklahoman — having lived in the state since 1960. He is married and has a four-year-old daughter.

I: This may seem like a silly question, but are you any relation to the Bob Wills from "Bob Wills and his Texas Playboys"?

Wills: No, I'm not, but I'm asked that all the time. I believe the son of Bob Wills still lives here in Norman. When Bob Wills died a few years ago, the newspapers ran an article saying his son lived in Norman, but didn't bother to say his name was Jim. There were quite a few confusing phone calls for a while.

I: How can you be a Visiting Assistant Professor when you're from OU?

Wills: I just say I'm visiting from southern Norman. Really, that situation stems from a larger problem. PhDs are going to and staying in business rather than academia. Consequently, there is a great shortage of qualified people to teach chemical engineering. We've had a permanent position open for almost a year now. As for my position, it's our catch-all, non-permanent, full-time position. It has been the department's policy not to hire OU graduates straight out of school. However, because of the need in the department for a teaching person, they have agreed to hire me temporarily.

I: Why doesn't the department hire OU graduates for teaching?

Wills: It's hiring OU graduates straight out of school that is the general restriction. As a matter of fact, Mark Townsend, our David Ross Boyd Professor, is an OU graduate. By not hiring people straight from this school, you avoid a channeling of thought into one mode or the development of a single philosophy.

I: Do you think your line of thought is too narrow?

Wills: No, not really. I haven't followed the typical pathway of a chemical engineer at OU. As a matter of fact, my BS is in zoology, while my MS and PhD are in chemical engineering. Also, many of the classes that I teach have changed quite a bit since I took them, particularly the freshman and sophomore classes. In every one, the text has changed.

I: How in the world did you go from zoology to chemical engineering?

Wills: Actually, I had a double major as an undergraduate, pursuing degrees in both zoology and biomedical engineering. After talking to the department chairman, Sam Sofer, I felt the best way to reach my goal — the design of artificial organs — was to get degrees in chemical engineering.

I: How does chemical engineering relate to human organs?

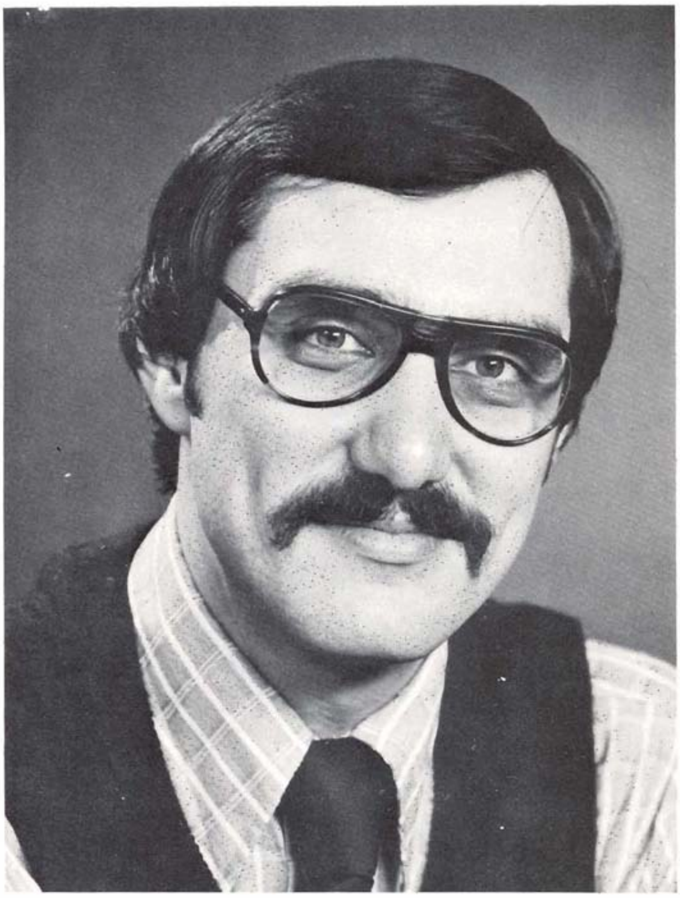
Wills: Quite well, as a matter of fact. Many of the things chemical engineers must study relate directly to body processes. For example, mass transport, membrane separation, and flow regimes for systems are all involved in dialysis or artificial kidney systems for kinetics. Reactor design and even computer programming relate directly to the liver-assist device that I'm doing research on at the present time.

I: Wouldn't you learn this as a biomedical engineer?

Wills: Not necessarily. Biomedical engineering, first of all, has been dropped at OU. Second, from my correspondence with industry and academia, it appears that biomedical engineering is being de-emphasized and more specialty engineers are being used; for example, electrical engineers for pacemaker work. Most of the biomedical engineering programs are either being phased out or made highly specialized, such as in cardiovascular work.

I: How do chemical engineers at OU get into the biomedical area?

Wills: Well, there are a couple of ways. One is that the students dig information out by themselves; they start asking questions around the department. Sometimes in class I'll be asked what type of research I do. My answers have brought students to me for more information. There is another way coming up this spring semester through a course I'll be teaching in biomedical engineering. I hope to let the students know that this field exists and that there are ways to do biomedical engineering without having that particular degree. I have had several pre-med chemical engineers interested in a course like this.



Dr. Robert Wills

I: What type of research do you do?

Wills: Right now it falls into two main areas, but I dabble in a little bit of everything. My main research is on an hepatic or liver-assist device. What we're doing is looking at ways to detoxify substances that enter the body which are not being detoxified by the liver. The device we're developing consists of two main units: a separator for getting at the toxins in the blood stream and a fluidized bed reactor in which we're using a biological catalyst for detoxification. My other main project is designing an artificial bloodvessel. I believe that I have a two-polymer combination that can be rolled into tubes that will work as an artificial blood vessel. The problems arising in this research are numerous because the body is so particular about what can be implanted. Despite the problems, I've enjoyed the work, and my students who assist me are really enjoying it also.

I: Do you intend to keep teaching?

Wills: Well, as I said before, my present position is temporary. Although I enjoy teaching, I would like to try full-time research. For now I'll just play it by ear.

The Russian Connection: Aldag Tells All

In the past, the Aldag family could be found spending summer vacations in Colorado or Illinois, visiting friends in Missouri, or even venturing south of the border to Texas. This year we decided to try something a little different, so we spent the summer in the Soviet Union. Our trip was a result of the US-USSR Exchange Program in Chemical Catalysis, and I spent my time as a visiting scientist in the laboratories of Professor O.V. Krylov at the Institute of Chemical Physics in Moscow. After the usual pedestrian preliminaries of renting our house and finding a place for the dog, we drove to Chicago on the 1st of May to catch a flight that eventually put us in Sheremetyevo Airport, north of Moscow.

My wife, Phyllis, and I had been in Moscow and several other parts of the Soviet Union the year before, so we had some reasonably accurate expectations about what the summer would be like, but it was the first time out of the country for our children (Laura 17, Lynda 14, and Jim 11). I think we both anticipated some problems associated with things like telephone, pizza, and TV withdrawal, but hoped that the cultural experiences could more than compensate. As it turned out, we all ate well, forgot entirely about the telephone and TV (with the exception of an occasional football game), and had plenty of cultural stimuli.

While Phyl and I were in Moscow last year, we visited some of the apartments provided to visiting scientists by the Academy of Sciences, so we had some idea of what our living accommodations would be. Our apartment was definitely austere and small — two bedrooms, one of which doubled as the living room, a bathroom, and an "efficiency" kitchen where we could reach about anything while we sat at the kitchen table. The kids organized themselves into one of the bedrooms and by the end of the summer became pretty good friends and sightseeing companions. In fact, after we all got unpacked and settled, we found the apartment fairly comfortable and we certainly couldn't beat the rent. The only thing that really bothered us were the rides in the elevator. (I think we found a new version of Russian Roulette.) Our building was fourteen floors but fortunately we lived on the fourth. There were always about four or five other American families in the building with us, and to their displeasure, they were all near the top.

The Aldags (Lynda, Art, Phyl, Jim, and Laura) in front of one of the cathedrals in Zagorsk

continued

The section of Moscow in which we lived contains most of the institutes and housing for the people who work in the Academy of Sciences. As a result, the shopping facilities are relatively good. Nonetheless, for a Westerner used to the supermarket culture, shopping in Moscow can be both interesting and frustrating. There are very few prepackaged foods and minimal use of refrigeration. Each store can be readily distinguished by its aroma. Bakery products are superb and usually quite fresh. Meats and vegetable products are adequate, although the best vegetables can be found at the Moscow "free market," where farmers sell produce grown on their own private plots at whatever price the market will bear. The old adage about "getting what you pay for" amply describes the difference between the government stores and the market. Unfortunately, the average Soviet monthly income of about 270 rubles precludes much extensive shopping at the free market. It is also about the only place to find fresh fruits. On the one occasion when oranges (from California) were available on the streets, the Soviets queued up for about a half a block. The quality of Soviet ice cream is well documented, and we all consumed a sufficient supply to verify the claims.

We found traveling around the city on public transportation quite easy and efficient. Their subway system is possibly one of the best in the world; without a doubt, the metro stations with their marble statues and mosaics are the most attractive. We never had more than a five-minute wait for a train, bus, or trolley. At a cost of about seven cents a ride, even those Muscovites who could afford a car (priced from about $10,000) generally opted for public transportation. In fact, the crowds on the buses were at times almost unbearable. Coming home one evening, I had the sense that all 8 million Muscovites were with me on the bus. We soon learned to avoid traveling, if possible, during certain periods of the day, and I generally walked to and from work. The countryside around

Moscow University on Lenin Hills

Moscow is very pleasant and picturesque, and although we were restricted to within 40 kilometers of the city without a special visa, on several occasions we took the train out to some of the small villages or went for a picnic in the forests.

The contrast between life in the city and the small villages is quite pronounced in the Soviet Union. My friends in Moscow generally had strong feelings about living in the city where there was "something to do." Moscow is definitely the "Big Apple" in the Soviet Union. Although there are indeed many things to do, the Soviet Union is far from being a consumer-oriented society. As I walked around Moscow, I had the sense of reliving the 1950s. There was very little of the splash of color or varied architecture that one associates with the cities in Western Europe or America. The older parts of Moscow, the churches, monasteries, and the Kremlin are very beautiful, but the newer buildings and apartments are generally very drab and sterile.

In the meantime, thoughts return to work. At the University of Oklahoma, we have been studying some of the catalytic properties of metal oxides which are active for the olefin metathesis or disproportionation reaction. Some of these catalysts also promote the partial oxidation of olefins, an area in which the group at the Institute of Chemical Physics has been active for some time. The Soviets have also become interested in the metathesis reaction, so we decided to compare some of the properties of a good methathesis catalyst (Re_2O_7) and olefin oxidation catalyst (MoO_3). My work this summer initiated the studies, and this year one of my graduate students (Mike Madden) will spend about six months in Moscow continuing the work. While I was there, we began by studying the heats of absorption of oxygen, propylene, and ethylene on MoO_3/Al_2O_3. We also did some work on catalyst characterization by I.R., EPR, x-ray photoelectron spectroscopy, and temperature programmed desorption. In general, the equipment was good, but the best instruments were purchased from outside the Soviet Union. By contrast, the other support facilities and working conditions left something to be desired. Supplies were often difficult to find, and on one occasion most of the work at the Institute came to a halt for two days when a scheduled delivery of liquid nitrogen never materialized.

Decembrist's Square in front of the Hermitage (Winter Palace). It was here that the massacre of 1905 occurred, eventually leading to the overthrow of the Russian Czar twelve years later.

Red Square and the Spasskaya Clock Tower. On the left is St. Basil, under scaffolding in preparation for the 1980 Olympics. The crowds on the right are queued to visit the Lenin Mausoleum.

On several occasions we could have saved some time by doing our lengthy catalyst pretreatments overnight, but at 5:00 p.m. the gas and, in some cases, the electricity were shut off. The laboratories were in general very cluttered and cramped, and apparently little thought had been given to matters of safety. Nonetheless, the people I worked with were good scientists, and I was impressed with the ingenious ways that they would work around the system to get things done. Overall, my work went quite satisfactorily, and we are currently preparing our results for publication and presentation at the 1980 US-USSR symposium in Irkutsk near Lake Baikal.

We were also able to do some traveling, and I visited several laboratories with active research programs in catalysis. On one exhaustive trip of two weeks, we traveled to Kiev in the Ukraine, Baku on the Caspian Sea, the Central Asian city of Alma Ata in the Kazak Republic, and Academic City outside of Novosibirsk in Siberia. By far, the best research facilities were in Academic City, a community founded about twenty years ago to foster the scientific pursuits of the Soviet Union. The setting is beatuiful — located on a huge manmade reservoir 200 miles across referred to by the locals as the "Ob Sea," and surrounded by a vast expanse of birch and pine forests. Unfortunately, the winters are about what one would expect for a place in Siberia. Still, some of the best and most innovative research comes from the laboratories in Novosibirsk. Each of the other cities maintains laboratories for the academy of science of the local republic, but none could match the massive effort expended in Novosibirsk.

Our final trip was to Leningrad, which I think is a truly unique city. We were there for three days at mid-summer during the celebrated "white nights." The Academy of Sciences was originally founded in Leningrad and later moved to Moscow. Although there are a number of institutes in Leningrad, the intensity of scientific activity is much less than that in either Moscow or Novosibirsk. There is little work in the area of catalysis, but I did spend some time with a group studying the absorption characteristics of molecular sieve compounds.

Leningrad is the most popular Soviet city with foreign tourists and still maintains the strong Western European character initiated by Peter the Great. Our three days were hardly enough to see all the things of interest to us. We could have easily spent a day or two in the art museum at the Hermitage, but Leningrad has so many other beautiful palaces and cathedrals from the Czarist Russian period that our time soon ran short. The overnight train ride from Moscow to Leningrad on the "Red Arrow" was also a unique experience of its own. The trains are clean, comfortable, and punctual, and the passengers spend most of the night singing, drinking, and partying.

The balance of our free time in Moscow was filled with ballet at the Bolshoi Theater or Kremlin Palace, several outings to the Moscow Circus and Gorky Park and walks along Arbat and Kalinin Prospect or through the Kremlin and Young Pioneers Palace. There were many pleasant evenings in the homes of our Soviet friends where the conversation was usually quite uninhibited and candid. Several of my colleagues had spent some time in the States, but most of them had impressions of the West that were highly distorted by censorship and carefully selected press releases. They would quiz me about the accuracy of things that they read in the local papers and devour the weekly news magazines and international newspapers that I would bring them.

I suspect that it is probably almost as difficult for us to appreciate what it is like to be a Soviet. A Russian in his fifties or sixties has been through so much and still lives under a tremendous level of bureaucracy and government regulation. My only observation would be that a system which requires so much control must be inherently unstable. The many exchange programs that have now been initiated with the Soviet Union foster a transfer of information on a professional level, but I think of equal importance is the opportunity for involvement with the people, their opinions, their goals and attitudes. For us the summer was a good one, filled with many fond memories. I think the Aldag family now has a better perspective of that part of the Soviet scene which functions beyond the political rhetoric.

View of the Kremlin from the Moskva River

The cathedral and clock tower at Zagorsk. The city is about 70 kilometers north of Moscow and is the site of the monastery founded by St. Sergius in 1337. It is one of the few working monasteries in existence in the Soviet Union.

Boards Join in Campus Meeting

The Boards of Directors of OkChE and the recently formed Foundation for Excellence met in a combined meeting on December 14, 1979. The boards heard reports on the status of CEMS, attended a luncheon with CEMS faculty, toured the recently improved undergraduate units operations laboratory, made plans for the coming year, met with Program of Excellence Scholars for refreshments and conversation, and capped the day with a dinner party at Barbara and Ken Starling's home.

Sam Sofer, CEMS director, presented an overview of the state of CEMS and discussed research in CEMS. Jay Radovich, CEMS undergraduate program coordinator, provided a status report on the undergraduate program and the many activities involving undergraduates. In addition, a discussion of the graduate program was presented by Carl Locke, CEMS graduate program coordinator, and a report on the various activities supported by OkChE funds was given by Ken

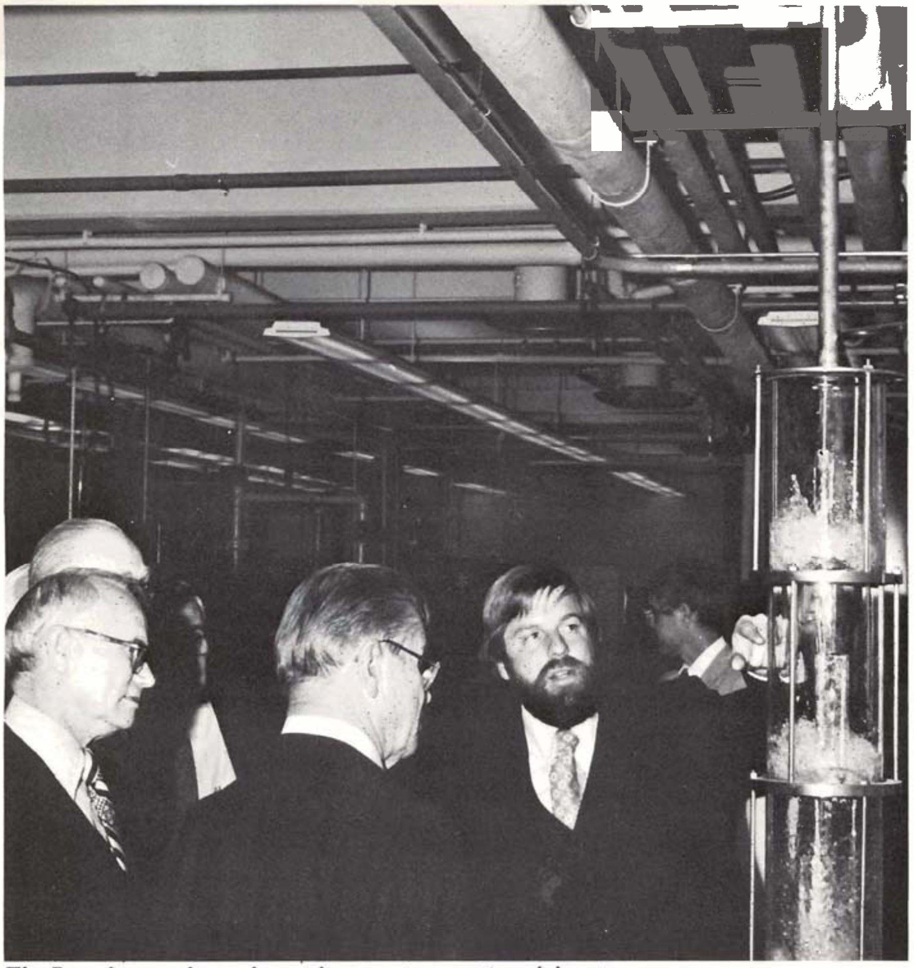
Combined Boards of OkChE and Foundation for Excellence

Starling. The OkChE Board voted to provide special support for further improvement of the unit operations laboratory and undergraduate scholarships next year, along with the usual support of student-related activities and alumni relations.

Members of the OkChE Board are Zane Johnson, president of the Gulf Science and Technology Company; Charles R. Perry, president of Perry Gas Companies; Richard Askew, vice president of Phillips Petroleum Company; Harold Bible, vice chairman of the board of Monsanto Company; Garman O. Kimmel, Kimray, Inc.; Raymond Lowe, vice president and general manager of E.I. DuPont DeNemours and Company; William Orr, president for the Lummus Company; J. Frank Wolfe, manager of Exxon Production Research Company; and Sam Sofer, director of the School of Chemical Engineering and Materials Science.

Members of the Foundation for Excellence Board are Verne Griffith, Jr., of the Ortloff Corporation; W.F. Wirges of the Cities Service Company; Bill Sellers of Sellers Chemical Corporation; Ed Lindberg, vice president of Warren Petroleum Company; Laurance Reid; and Mr. Richard Askew and Charles R. Perry, who are also members of the OkChE Board.

Time out for a social hour



The Boards tour the undergraduate units opeations laboratory.

Third Charles Perry Challenge Met, Fourth Challenge Made!

The third Charles Perry Challenge, in which Charles Perry/Perry Gas Companies, Inc., have matched contributions to OkChE by alumni and friends, has been met. According to the rules of the challenge, the first $10,000 contributed to OkChE from October 1, 1978 through September 30, 1979 would be matched by Perry. Thus, with matching company funds, contributions to OkChE have exceeded $20,000 for the third year in a row!

Charles Perry has announced that he is issuing a fourth challenge. Contributions to OkChE by individuals made between the dates of October 1, 1979 and September 30, 1980 will be matched, up to a total of $10,000. Thus, the great opportunity to have your contribution to OkChE matched dollar-for-dollar is available again this year. Remember that your contribution to OkChE is tax deductible and that many companies match employee contributions.

Alumni Notes

Let us know where you are and what you are doing. Please fill out one of the enclosed information cards and send it to us. We will publish the information in our next issue of OkChE.

Deaths

Colon V. Bickford, BS '38, MD '46, 2405 Bon Aire, Victoria, TX 77901, died on March 11, 1979, following surgery.

1940s

W. Jack Anderson, BS '43, 3924 Antone Road, Santa Barbara, CA 93110, took an early retirement in 1975 to set up his own consulting firm. He and his wife, Betty, just celebrated their 35th anniversary.

Gerald A. Conger, BS '43, RD 5 Box 401, Dallas PA 18612, is a self-employed foundry and metallurgical consultant, working on projects in Mexico and South America.

Julian Friedman, BS '42, 1110 W. Beltline, Box 614, Alton, IL 62002, recently started an energy management consultants division to work with business and industry in developing energy conservation programs.

G. L. McCurry, BS '41, 6930 E. 62nd Street, Tulsa, OK, serves as vice president and manager of operations for C. E. Crest.

Louis W. Miller, Sr., BS '48, 10822 Archmond, Houston, TX 77070, retired from Conoco in June 1975, and is now vice president of Delaware Trading Company.

1950s

Frank P. Williamson, BS '50, 13034 Hermitage Lane, Houston, TX 77079, works as engineering advisor for the Carter Oil Company.

1960s

Burtis L. Espy, BS '61,1208 Pampas Lane, League City, TX 77573, former market research consultant with the Pace Co., is now a senior intern at Texas Chiropractic College.

W. A. Kennedy, Jr., '66, 7616 Clayton Dr., Oklahoma City, OK 73132, is director of operations for the Corken International Corp. He is married and has two children.

G. Ali Mansoori, PhD '69, 17347 Oleander Ave., Tinley Park, IL 60477, is professor of chemical engineering at the University of Illinois at Chicago Circle.

1970s

Larry Airington, BS '72, MBA '75, Diamantvn 22, 4300 Sandnes, Norway, is working as an economics engineer for the Greater Ekofisk Area Project. He and his wife, Susan, have a daughter, Megan, born June 8, 1979.

Jeffrey C. Arnoldi, BS '76, 2331 Broadlawn Dr., Houston, TX 77058, works for Celanese as a process engineer.

Dale R. Deain, BS '72, 1801 Neal, Navasota, TX 77868, is employed as chief metallurgical engineer with Tubular Finishing Works.

Hafez-Hafezzadeh, MS '77, P.O. Box 4615, Springfield, MO 65804, is a project engineer with Syntex, Inc.

Robert S. Purgason, BS '78, 4675 Oakwood, #129, Odessa, TX 79761, is manager of operations for Perry Gas Processors.

Ken E. Sanders, MS '71, PhD '73, 11913 Bayswater Road, Gaithersburg, MD 20760, is working as an engineer with the Nuclear Regulatory Commission in Washington.

David Sparkman, BS '72, 1933 Grand Ave., New Castle, IN 47362, is quality control manager and plant metallurgist for Dana Corp.

David R. Starkey, BS '72, 3409 Cobblestone, Baytown, TX 77521, is employed as technical section supervisor for Exxon Chemical Co. He is married and has two children.