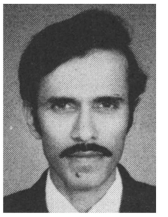
nuclear technology®

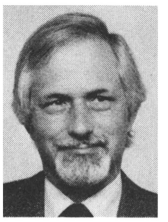
AUTHORS — FEBRUARY 1981

FISSION REACTORS

CALIBRATION OF ELECTROCHEMICAL OXYGEN METERS FOR SODIUM IN STATIC TESTS AND IN THE SODIUM LOOP

N. P. Bhat
H. U. Borgstedt

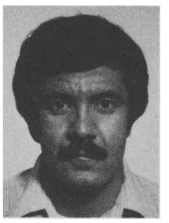


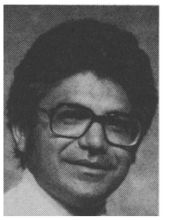


N. P. Bhat (top) (MSc, chemistry, Bombay University) began working with the Bhabha Atomic Research Centre (BARC) in 1963. At present he is with Reactor Research Centre (RRC) in India. In 1977 and 1978, he was deputed under an International Atomic Energy Agency fellowship to Kernforschungszentrum Karlsruhe (KfK) to do research in sodium chemistry. As group leader of the Analytical Chemistry Group of the Radiochemistry Laboratory at RRC, he is working on impurity characterization and measurement in sodium and related analytical chemistry problems for the Fast Breeder Test Reactor. **Hans U. Borgstedt** (Dr. rer. nat., chemistry, University of Karlsruhe, 1959) is a section head at KfK. Since 1963, he has been engaged in sodium corrosion work. His current interests are in alkali metal influences on material properties.

ROLE OF CONDENSATION IN AEROSOL SOURCE TERM FOR LIQUID-METAL FAST BREEDER REACTOR CONTAINMENTS

A. A. Emami
S. K. Loyalka

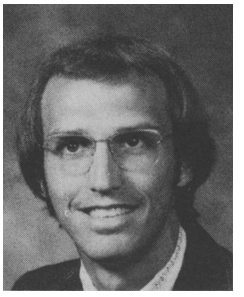




Aliakbar Emami (top) (BS, chemical engineering, 1976, and MS, 1977, and PhD, 1980, nuclear engineering, University of Missouri-Columbia). **Sudarshan K. Loyalka** (BS, mechanical engineering, University of Rajasthan, India, 1964; MS, 1965, and PhD, 1967, nuclear engineering, Stanford University) is professor of nuclear engineering at the University of Missouri-Columbia. During the years 1969 to 1971 he was a visiting scientist at the Max Planck Institut für Strömungsforschung in Göttingen, Federal Republic of Germany.

TRITIUM BREEDING MANAGEMENT IN THE HIGH YIELD LITHIUM INJECTION FUSION ENERGY CHAMBER

Wayne R. Meier

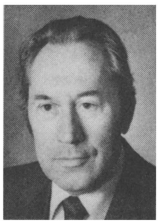


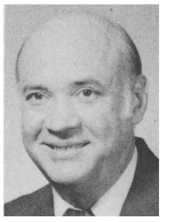
Wayne R. Meier (BS, physics, Western Illinois University, 1974; MS, nuclear engineering, University of Illinois, 1976) is a research engineer in the Energy and Military Applications Group of the Laser Fusion Program at Lawrence Livermore National Laboratory. He has been involved in the conceptual design of various reactor concepts for inertial confinement fusion (ICF) for the past four years. His current technical interests include neutronics, fusion-fission hybrids, and the economics of ICF electric power plants.

NUCLEAR SAFETY

STATISTICAL EVALUATION OF DESIGN-ERROR RELATED NUCLEAR REACTOR ACCIDENTS

K. O. Ott
J. F. Marchaterre



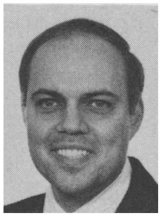


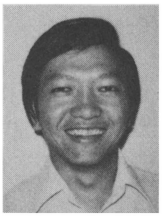
Karl O. Ott (top) (PhD, theoretical physics, Georg August University, Göttingen, 1958) is a professor in the School of Nuclear Engineering of Purdue University and a consultant to Argonne National Laboratory and Los Alamos Scientific Laboratory. Presently he is on leave from Purdue University, acting as head of the Applied Systems Analysis Group, Angewandte Systemanalyse, in the Federal Republic of Germany. His research interests include fast reactor neutronics, fuel cycle and safety analysis, risk assessment, and safety analysis of large-scale technological systems. **J. F. Marchaterre** (BS, MS, engineering, chemical engineering, Michigan Technological University) is an associate division director, Reactor Analysis and Safety Division, Argonne National Laboratory. He has been doing reactor research and development work since 1955 and was active in early boiling water reactor development and for the past ten years he has been working in fast reactor safety.

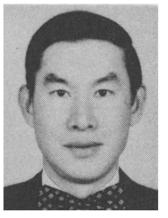
FUEL CYCLES

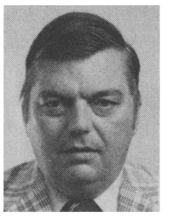
THE BENEFITS OF CYCLE STRETCHOUT IN PRESSURIZED WATER REACTOR EXTENDED-BURNUP FUEL CYCLES

R. A. Matzie
D. C. Leung
Y. Liu
R. W. Beekmann





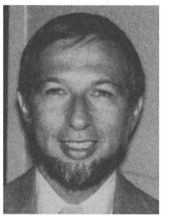




R. A. Matzie (top right) (BS, physics, U.S. Naval Academy, 1965; MS, 1971, and PhD, 1976, nuclear engineering, Stanford University) is the supervisor of Advanced Design Projects at Combustion Engineering, Inc. (C-E). His current technical interests include the thorium fuel cycle, methods of improving uranium utilization in current design light water reactors, advanced converter reactors, and plutonium recycle. **D. C. Leung** (top left) (BS, chemical engineering, Washington State University, 1971; MS, 1973, and PhD, 1977, nuclear engineering, University of Illinois at Champaign-Urbana) is a senior engineer in the Advanced Design Projects Group of C-E. His current technical interests include fuel cycles, fuel management, and core analysis of pressurized water reactors. **Y. Liu** (bottom right) (BS, mechanical engineering, Naval College of Technology, Taiwan, Republic of China; Dipl.-Ing. and Dr.-Ing., nuclear engineering, Technische Hochschule Aachen, Federal Republic of Germany) is a principal engineer in the Advanced Design Projects Group of C-E. His interests include fuel management, fuel cycle studies, alternate reactor concepts, and plutonium recycle. **R. W. Beekmann** (bottom left) (BSE, science engineering, 1960, and MS, nuclear engineering, 1962, University of Michigan; PhD, nuclear engineering, University of Washington, 1968) was a principal investigator in the Nuclear Fuel Cycle Analysis and Economics Group of C-E. His current technical interests include all areas of the nuclear fuel cycle, including the economic and contractual aspects.

SIMPLIFIED PROCEDURES FOR FAST REACTOR FUEL CYCLE AND SENSITIVITY ANALYSIS

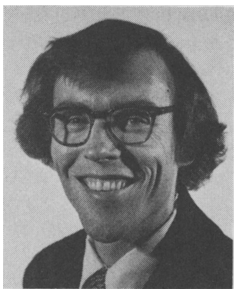
Ahmed Badruzzaman
Martin Becker



Ahmed Badruzzaman (top) [BSc, Hons., physics, University of Dacca, 1968; MSc, 1969, and MPhil, 1970, theoretical physics, University of Islamabad; MS, physics, State University of New York at Albany, 1977; MEng, 1977, and PhD, 1979, nuclear engineering, Rensselaer Polytechnic Institute (RPI)] is an engineer with the Nuclear Power Generation Division of the Babcock and Wilcox Company. The material of the present paper was a part of his graduate work at RPI. Areas of his special interest are extended burnup light water reactor fuel cycles, and liquid-metal fast breeder reactor core designs and reactor theory. **Martin Becker** (BS, New York University, 1960; SM, 1962, and PhD, 1964, Massachusetts Institute of Technology) is professor of nuclear engineering and director of the Center for Technology Assessment at RPI. He has been active in research, authoring or co-authoring over 150 publications. He has served on federal and state advisory panels. His current interests include reactor physics, mathematical methods, thermal-hydraulic stability, utility system modeling, and energy modeling. He also has consulted for many industrial, regulatory, and national laboratory organizations directly and through the firm of Becker, Block, and Harris, Inc. in the above areas and in such other areas as plant operating reliability, operator roles at power plants, nuclear fuel cycle analysis, and plant instrumentation. He is an editor of the series *Advances in Nuclear Science and Technology*. He is a fellow of the American Nuclear Society and a senior member of the Institute of Electronical and Electronics Engineers. He is a registered professional engineer in the State of New York.

BOW IN EXPERIMENTAL BREEDER REACTOR II REFLECTOR SUBASSEMBLIES

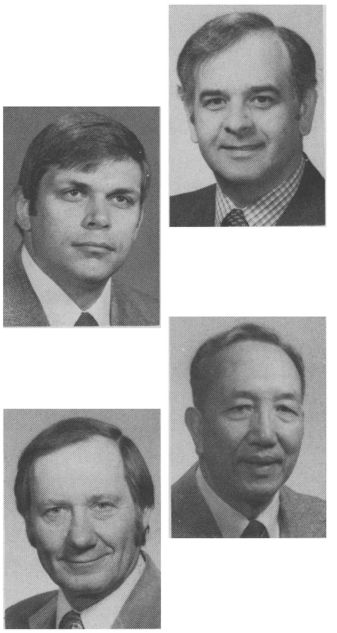
J. A. Shields, Jr.



John A. Shields, Jr. (BS, metallurgy, 1968, MS, metallurgy and materials science, 1971, and PhD, 1975, Case Western Reserve University) has been an assistant professor of metallurgical engineering at Wayne State University since 1979. From 1974 to 1979, he was associated with the Experimental Breeder Reactor II Project of Argonne National Laboratory. His current areas of interest are structure-properties relations in dual-phase and alloy steels, as well as the effects of irradiation on component performance in liquid-metal fast breeder reactor systems.

TREAT TEST L5 SIMULATING AN LMFBR LOSS-OF-FLOW ACCIDENT WITH FTR-TYPE IRRADIATED FUEL

Richard Simms
Stephen M. Gehl
Robert K. Lo
Alan B. Rothman



Richard Simms (top right) (BChE, chemical engineering, Cooper Union, 1959; PhD, nuclear engineering, Massachusetts Institute of Technology, 1964) is currently a nuclear engineer in the Reactor Analysis and Safety (RAS) Division at Argonne National Laboratory (ANL). His current research interests are in the planning, conduct, and analysis of in-pile experiments in the liquid-metal fast breeder reactor safety program. **Stephen M. Gehl** (top left) (BS, metallurgical engineering, University of Notre Dame, 1969; PhD, materials science and engineering, University of Florida, 1977) is with the Materials Science Division at ANL. He is conducting research on the response of oxide and carbide nuclear fuels to thermal transients, with emphasis on fission product effects and microstructural changes. **Robert K. Lo** (bottom right) (BS, aeronautical engineering, National Central University, China, 1944; MS, mechanical engineering, Stanford University, 1951; PhD, Illinois Institute of Technology, 1957) has been with ANL as an experimental analyst since 1966. **Alan B. Rothman** (bottom left) (BS, chemistry, University of Pittsburgh, 1949; MS, chemistry, 1952, and PhD, physical chemistry, 1954, Carnegie Institute of Technology) is currently Transient Reactor Test Facility Program Experiments Section Manager in the RAS Division at ANL. His special interests include thermodynamics, reactor physics, and nuclear engineering.

FULL-FLUENCE TESTS OF EXPERIMENTAL THERMOSETTING FUEL RODS FOR THE HIGH-TEMPERATURE GAS-COOLED REACTOR

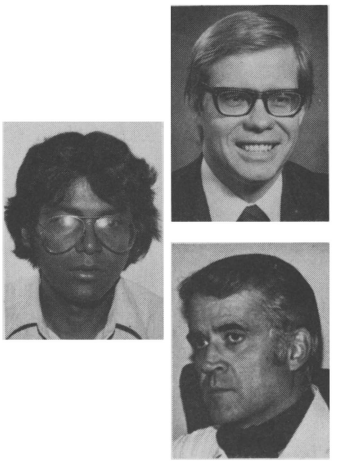
Ronald E. Bullock

Ronald E. Bullock (BS, physics, Louisiana Polytechnic Institute, 1956; MA, mathematics, 1963, and MS, physics, 1969, Texas Christian University) has been with General Atomic Company since 1973, where he has worked on nuclear fuel technology for high-temperature gas-cooled reactors. His specialty concerns the statistical behavior of brittle materials under the influence of irradiation. He has worked in nuclear research since 1956, with prior experience in the Aircraft Nuclear Propulsion and Nuclear Engine for Rocket Vehicle Applications Programs.

RADIOACTIVE WASTE MANAGEMENT

AN ANALYSIS OF DIFFUSIONAL ION TRANSPORT IN OCEAN SEDIMENTS: SUBSEAFLOOR DISPOSAL OF RADIOACTIVE WASTE

Herbert E. Nuttall
Asit K. Ray
E. James Davis



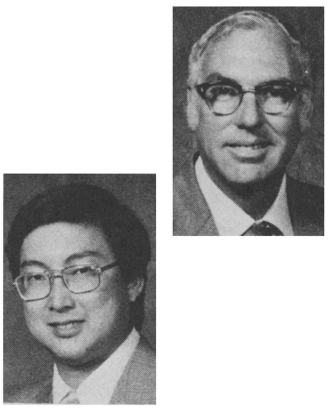
Herbert E. Nuttall (top) (BS, chemical engineering, University of Utah, 1966; MS, 1968, and PhD, 1971, chemical engineering, University of Arizona) is associate professor of chemical engineering at the University of New Mexico and is a consultant to Sandia National Laboratories on the Seabed Program. His current research includes fossil fuel recovery and nuclear waste isolation. **Asit K. Ray** (center) (BS, chemical engineering, Indian Institute of Technology, Kharagpur, 1975; MS, 1977, and PhD, 1980, chemical engineering, Clarkson College of Technology) is a post-doctoral fellow at the University of New Mexico. He has over a dozen publications on heat and mass transfer associated with aerosols and nuclear waste migration. **E. James Davis** (bottom) (BS, chemical engineering, Gonzaga

University, 1956; PhD, chemical engineering, University of Washington, 1960) has recently become director of the Engineering Division of the Institute of Paper Chemistry in Appleton, Wisconsin. During the collaboration on the paper, he was professor and chairman of chemical and nuclear engineering at the University of New Mexico. He has authored ~70 papers in the areas of transport phenomena, mathematical modeling, and aerosol physics and chemistry.

MATERIALS

IN-REACTOR CREEP MEASUREMENTS

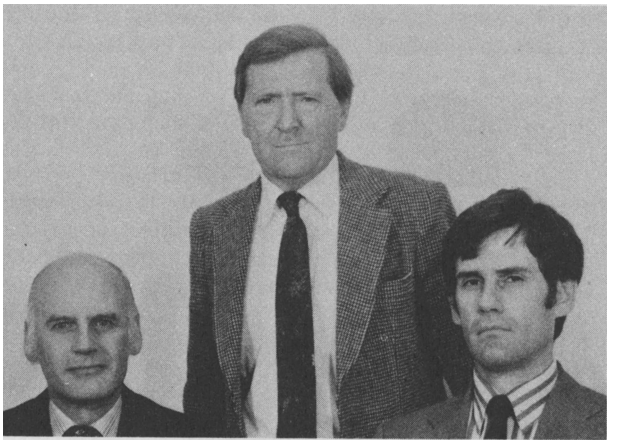
E. R. Gilbert
B. A. Chin



E. Robert Gilbert (left) (BS, 1961, and MS, 1962, physical metallurgy, and PhD, engineering sciences, 1970, Washington State University) investigated mechanical and physical properties of metal fuels and developmental cladding alloys at Argonne National Laboratory from 1962 to 1966. In 1966 he assumed responsibility for in-reactor creep studies of cladding materials for water and liquid-metal fast breeder reactors for Pacific Northwest Laboratory at Richland, Washington. Since 1970 he has been with Westinghouse Hanford Company, developing new testing methods to produce statistical quantities of in-reactor creep data for numerous commercial and developmental advanced alloys for fast breeder reactor core applications. **Bryan A. Chin** (BS, mechanical engineering, Auburn University, 1973; MS, materials science, Stanford, 1975; PhD, materials science, Stanford, 1976) is manager of the Irradiation Creep Section of Westinghouse Hanford Company. Since 1976, he has been involved in materials characterization for advanced reactor and fusion energy systems.

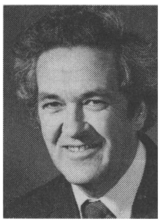
THE APPLICATION OF HIGH GRADIENT MAGNETIC SEPARATION IN NUCLEAR FUEL REPROCESSING

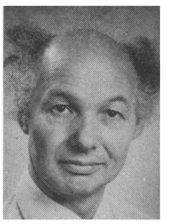
J. A. Williams
W. Baxter
G. Collins
K. Harding
C. M. Leslie
R. J. Sills



John A. Williams (group photo, center) (BS, chemistry, London, 1944, fellow, chemical engineering, Institution of Chemical Engineers, London) has published papers on pulsed-column and mixer settler design, multistage solvent extraction calculation methods, the nuclear fuel cycle, and irradiated fuel transport. Williams worked in the chemical industry and in 1952, joined Windscale in the Research and Development Department. In 28 years in the nuclear reprocessing industry, he has been responsible for the development of plutonium purification plants, the reprocessing plants at Dounreay, and for parts of the Magnox reprocessing plant at Windscale. He has traveled widely for negotiation of reprocessing contracts in Japan, Europe, and the Far East. At present, he is in charge of the British Nuclear Fuels Limited (BNFL) Technical Section, which has teams dealing with shielding, criticality, heat transfer, mass transfer, stress analysis, and safety for new reprocessing plants. **Warren Baxter** (single photo, top) (Chartered Chemist; graduate, 1957, associate, 1959, and fellow, 1971, Royal Institute of Chemistry) has been engaged in development work in nuclear fuel reprocessing with the United Kingdom Atomic Energy Authority (UKAEA) and BNFL for 26 years. During this time he has worked on a number of topics such as fuel dissolution, solvent extraction processes, and uranium/plutonium separation, but

for the last five years he has been working mainly on waste treatments. He is currently group manager of wastes technology in the Research and Development Department at Windscale. **Gerald Collins** (single photo, center) (BS, Brunel University, 1961; PhD, electrostatics, Bath University, 1968; chemical engineering, MIEE) is an assistant manager in the Fuels Technology Division, Dounreay Nuclear Power Development Establishment, UKAEA, and has been working on gas and liquid filtration systems. Before 1977, he worked on gas discharge and plasma microwave devices. **K. Harding** (single photo, bottom) (CChem, MRIC, Barnsley College of Technology, 1955) worked for the Coal Board on mine safety, then in 1958, joined UKAEA's Atomic Energy Establishment, Winfrith, where he worked on water reactor development. He is currently the section leader responsible for chemical plant development and is primarily concerned with nuclear waste recovery and treatment. **Colin M. Leslie** (group photo, left) (BS, chemistry, St. Andrews University; post-graduate diploma, chemical engineering, Imperial College, London; MIChemE, chemical engineering) worked for 15 years in the petrochemical industry before joining BNFL in 1975. His main field of activity is the reprocessing of fast reactor fuels, in particular, long-term projects aimed at reducing or eliminating discharges to the environment. **Richard J. Sills** (group photo, right) (BS, chemistry, 1967, and PhD, inorganic chemistry/crystallography, 1970, University of Birmingham) is an assistant manager of research and development in BNFL's Reprocessing Division. His work since joining BNFL in 1970 has been concerned with chemical and physical research and development studies in nuclear fuel enrichment and reprocessing technologies.



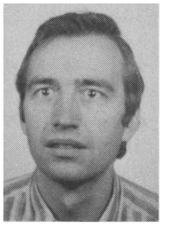


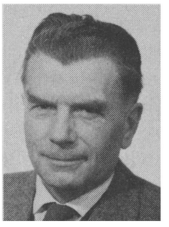
TECHNIQUES

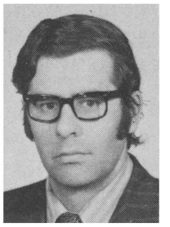
FISSION TRACK ANNEALING AND FISSION TRACK AGE-TEMPERATURE RELATIONSHIP IN SPHENE

T. D. Märk
M. Pahl
R. Vartanian

Tilmann D. Märk (top) (PhD, physics, 1968, and Univ. Doz., atomic physics, 1976, University of Innsbruck, Austria) spent one and a half years as Max Kade Fellow in the University of Minnesota, Department of Electrical Engineering, Minneapolis from 1969 to 1971 and one year as CIRES Visiting Fellow in the University of Colorado, Department of Chemistry, Boulder (1979/1980). He joined the University of Innsbruck Faculty in 1968 and is presently professor of atomic physics at the Institut für Experimentalphysik of the University of Innsbruck. His research interests include fission tracks physics, electron impact ionization, and ion molecule reactions. **M. Pahl** (center) (PhD, physical chemistry, 1934, and Dr. rer. nat. habil., 1939, University of Freiburg) joined the Kaiser Wilhelm Institut für Physik in 1943, and went to the Max Planck Institut, Göttingen, in 1950. He has been a full professor of atomic physics since 1966 at the faculty of University of Innsbruck (Emeritus since 1978). His work has been in the area of natural radioactivity, gas discharges, kinetics of elementary processes, and fission track application to geothermochronology. **R. Vartanian** (bottom) (Dipl. Phys., physics, University of Bern, Switzerland, 1972; PhD, physics, University of Innsbruck, Austria, 1975) joined the Nuclear Research Center of the Atomic Energy Organization of Iran, Tehran, in 1975. His primary research interest is fission track physics and its applications.



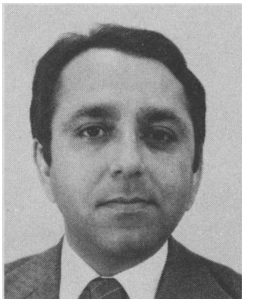




FISSION REACTORS

ON THE MINIMUM OVERALL SIZE OF A REFLECTED PEBBLE-BED REACTOR

R. Chawla

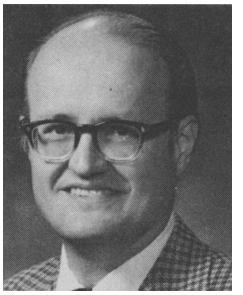


Rakesh Chawla (BSc, Hons. School, physics, Panjab University, 1966; MSc, 1967, and PhD, 1970, nuclear power, Imperial College, University of London) joined the Swiss Federal Institute for Reactor Research in 1978. He worked at the U.K. Atomic Energy Establishment, Winfrith, from 1968 to 1972, and taught at the Indian Institute of Technology, Kanpur from 1972 to 1978. His areas of research have included experimental reactor physics, assessment of reactor calculational methods and data, and radioisotope applications.

CHEMICAL PROCESSING

AN EMPIRICAL EQUATION FOR ESTIMATING NITRIC-ACID EXTRACTION BY TRI-*n*-BUYTL PHOSPHATE FROM NITRIC ACID AND NITRIC-ACID/SODIUM-NITRATE SOLUTIONS

J. C. Mailen

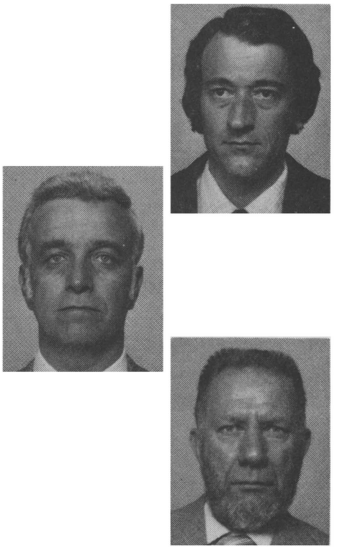


J. C. (Jim) Mailen (PhD, chemical engineering, University of Florida, Gainesville, 1964) has been involved in fuel cycle research in the Chemical Technology Division at Oak Ridge National Laboratory since 1963. He is currently group leader for laboratory development with technical interests in solvent extraction processes and fuel dissolution behavior.

ANALYSIS

CALCULATION OF NEUTRON DIE-AWAY TIMES IN A LARGE-VEHICLE PORTAL MONITOR

R. A. Lillie
R. T. Santoro
R. G. Alsmiller, Jr.



R. A. Lillie (top) (PhD, University of Tennessee, 1975) is a research staff member in the Engineering Physics Division at Oak Ridge National Laboratory (ORNL). His work has been in the areas of fission reactor core physics and shielding analysis. His current interests focus on the application of radiation transport methods to fusion reactor neutronics problems. **R. T. Santoro** (center) (MS, University of Tennessee, 1967) is a research staff member in the Engineering Physics Division at ORNL. His interests focus on magnetic fusion energy reactor design, particularly on the analysis of neutronics problems related to shielding, neutral beam injectors, and integral experiments. **R. G. Alsmiller, Jr.** (bottom) (PhD, University of Kansas, 1957) is leader of the Applied Physics and Fusion-Reactor Analysis Group of the Engineering Physics Division at ORNL. For several years he has directed theoretical research in this division in the areas of high-energy nuclear reactions, high-energy nuclear transport, and fusion reactor neutronics.