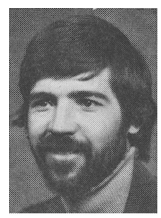
nuclear technology®

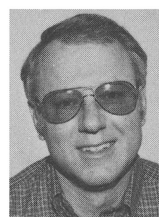
AUTHORS — OCTOBER 1983

FISSION REACTORS

URANIUM-PLUTONIUM CARBIDE FUEL FOR FAST BREEDER REACTORS

R. Bruce Matthews
Richard J. Herbst



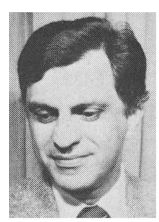


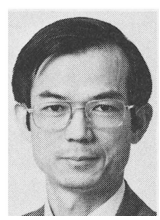
R. Bruce Matthews (top) (BS, metallurgy, The Pennsylvania State University, 1964; PhD, materials science, University College Swansea, 1970) is project leader for the Advanced Carbide Fuel Development Program at Los Alamos National Laboratory (LANL). His current interests are fabrication development, irradiation testing, and postirradiation analysis of ceramic nuclear fuels. **Richard J. Herbst** (BS, MS, and PhD, ceramic engineering, University of Illinois, 1963) is program manager for Breeder Nuclear Technology Projects at LANL. His current interests are design and assessment of advanced cores for breeder reactors.

NUCLEAR SAFETY

GENERAL FORMULATION OF AN HCDA BUBBLE RISING IN A SODIUM POOL AND THE EFFECT OF NONEQUILIBRIUM ON FUEL TRANSPORT

G. Kocamustafaogullari
S. H. Chan

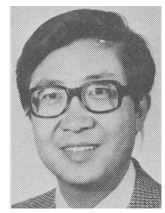


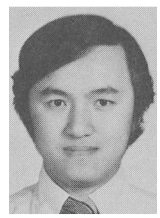


G. Kocamustafaogullari (top) (PhD, mechanical engineering, Georgia Institute of Technology, 1972) completed a year as a postdoctoral research associate at the same institution on the investigation of multiphase structured media. The next six years were spent at the Istanbul National Academy of Engineering and Architecture in Turkey. Since 1980, he has been with the Mechanical Engineering Department, University of Wisconsin-Milwaukee. His recent interests include the thermal-hydraulic analysis of breeder and water reactors, boiling heat transfer, and modeling of two-phase flow systems. **S. H. Chan** (PhD, mechanical engineering, University of California-Berkeley, 1969) is a professor and chairman of the Department of Mechanical Engineering, University of Wisconsin-Milwaukee. Previously he taught in New York and was on the research staff in the Reactor Analysis and Safety Division at Argonne National Laboratory. His current research areas include thermal radiative transfer, thermal radiation properties of reactor materials, thermal-hydraulic analysis of breeder and water reactors, heat transfer and fouling heat transfer in geothermal energy systems.

THREE-DIMENSIONAL NUMERICAL ANALYSIS OF NATURAL CONVECTION OF COMPACTED SPENT FUEL

James M. Wu
Chun-Fa Chuang

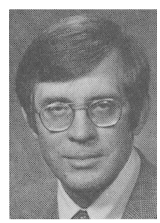


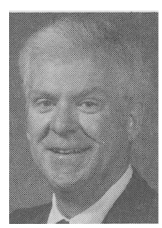


James M. Wu (top) (BS, chemical engineering, Tunghai University, 1965; PhD, engineering science, State University of New York at Buffalo, 1972) was a senior engineer with Bechtel Power Corporation from 1973 to 1979. Since 1979, he has been an associate professor in the Nuclear Engineering Department at the Rensselaer Polytechnic Institute. His current research interests include waste incineration technology, iodine behavior in reactor water, and reactor accident analysis. **Chun-Fa Chuang** (BS, 1972, and MS, 1976, nuclear engineering, Tsing Hwa University; PhD, nuclear engineering, Rensselaer Polytechnic Institute, 1983) joined the Engineering Division of Argonne National Laboratory recently. He is involved in nuclear thermal-hydraulic design and safety analysis. Before coming to the United States, he worked in the area of heavy water reactor operation at the Institute of Nuclear Energy Research in Taiwan from 1976 to 1979.

CONTROLLED BIAXIAL STRAIN-RATE TESTING OF 20% COLD-WORKED TYPE 316 STAINLESS STEEL FAST REACTOR CLADDING

N. Scott Cannon
Gary L. Wire

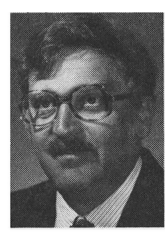


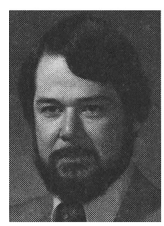


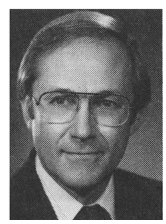
N. Scott Cannon (top) (PhD, solid state physics, University of Utah, 1976) is a senior engineer at Westinghouse Hanford Company (WHC). He has been involved in investigating breeder reactor clad properties under transient conditions, and has developed sophisticated computerized test systems to simulate transients under a variety of clad temperature, stress, and strain paths. **Gary L. Wire** (PhD, solid state physics, University of Illinois, 1972) was manager at WHC of the group with responsibility for development of postirradiation flow and fracture test techniques for alloy development and qualification. He has been active in the application of the mechanical equation-of-state concept to generate improved mechanical property correlations for safety analysis of breeder reactor components.

FUEL-CLADDING MECHANICAL INTERACTION IN PCI-RESISTANT LWR FUEL DESIGNS DURING NORMAL OPERATION AND POWER RAMPING

John O. Barner
Richard J. Guenther
Maxwell D. Freshley
Carl E. Crouthamel

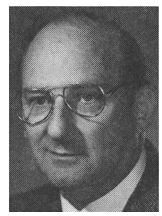






John O. Barner (top) (BS, ceramic engineering, University of Washington, 1961; MS, engineering, University of California-Berkeley, 1963) is a staff engineer in the Nuclear Fuels Section at Battelle's Pacific Northwest Laboratory (PNL). His main interest has been in the development of liquid-metal fast breeder reactor (LMFBR) and light water reactor (LWR) fuels. He is presently involved in both fuel development and radioactive waste disposal. **Richard J. Guenther** (center) (BS, engineering physics, 1969; MS, nuclear engineering, Oregon State University, 1978) is a research engineer in the Nuclear Fuels Section at PNL. His main area of interest has been the in-reactor performance of LWR and LMFBR fuels. He is currently involved in fuel rod code performance evaluations and assessment of dry fuel storage. **Maxwell D. Freshley** (bottom) (BS, physics, University of

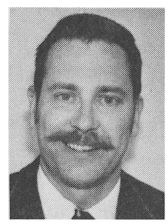
Portland, 1951) is currently manager of the Nuclear Fuels Section at PNL. He has been involved for several years in evaluating the performance of nuclear fuels. **Carl E. Crouthamel** (right) (BS, chemistry and mathematics, Eastern Nazarene College, 1942; MA, analytical chemistry, Boston University, 1943; PhD, inorganic chemistry, Iowa State University, 1950) is currently a consultant in the Fuel Performance and Advanced Fuel Design and Analysis Group at Exxon Nuclear Company.

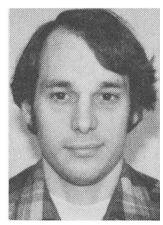


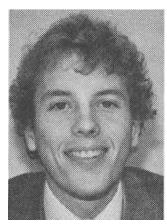
RADIOACTIVE WASTE MANAGEMENT

DEVELOPMENT OF A LEACH MODEL FOR A COMMERCIAL NUCLEAR WASTE GLASS

William L. Kuhn
Richard D. Peters
Scott A. Simonson





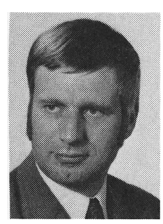


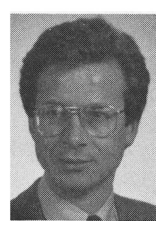
William L. Kuhn (top) (BS, chemical engineering, Lafayette College, 1967; PhD, chemical engineering, University of Washington, 1974) is a senior R&D engineer at Battelle's Pacific Northwest Laboratory (PNL), where he is working on nuclear waste isolation, vitrification, and process safety. He is also a lecturer at the Joint Center for Graduate Study, Richland, Washington, where he teaches courses on transport phenomena, mass transfer, thermodynamics, and fluid dynamics. His current technical interests include developing models of long-term physicochemical behavior in nuclear waste packages. **Richard D. Peters** (center) (BS, chemistry, University of the Pacific, 1975; MS, chemical engineering, University of California-Berkeley, 1978) is an R&D engineer at PNL. He is currently working on analysis of nuclear waste form performance in repositories and development of effluent control systems for waste vitrification facilities. **Scott A. Simonson** (bottom) (BS, nuclear energy, University of Illinois, 1981; MS, nuclear engineering, University of Illinois, 1983) recently completed master's degree work in the area of mathematical modeling of nuclear waste form leach behavior. He has since joined the staff at PNL as an R&D engineer working on mathematical models used in the design and performance assessment of nuclear waste packages.

ECONOMICS

DECOMMISSIONING OF LARGE NUCLEAR POWER PLANTS WITH LWRs IN THE FEDERAL REPUBLIC OF GERMANY

Gerhard V. P. Watzel
Ingolf Auler



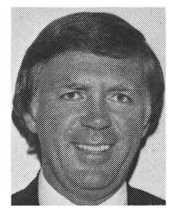


Gerhard V. P. Watzel (top) (MS, mechanical engineering, 1963; Dr. Eng., Technical University of Darmstadt, 1969) did research work for five years at the Institute for Thermodynamics at Darmstadt before starting work at Rheinisch Westfälisches Elektrizitätswerk's head office at Essen in 1969. His main interests are general safety conceptual and risk evaluations for nuclear power stations, protection against external events, and special decommissioning projects. **Ingolf Auler** (Ing. grad., nuclear engineering, Fachhochschule Essen, 1967) has worked in the area of decommissioning of nuclear facilities since 1972. He is deputy department manager at the Engineering Department of NIS Nuklear-Ingenieur-Service GmbH, Hanau. He is presently engaged in the planning of protective storage of the NPP Gundremmingen Unit A.

MATERIALS

NUCLEAR COMPONENT WEAR MEASUREMENTS

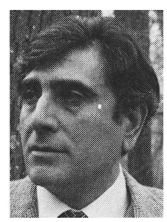
Keith F. Dufrane
Michael D. Naughton



Keith F. Dufrane (top) (BS, 1963, and MS, 1964, metallurgical engineering, Michigan Technological University) has worked in the area of tribology at Battelle's Columbus Laboratories since graduation. His interests center on wear and failure analysis involving friction, wear, and lubrication. **Michael D. Naughton** (BS, chemistry, St. Thomas College, 1957) has specialized in power plant radiation control for much of his career, including 13 years with the electric utilities. Since 1978 he has been with the Nuclear Power Division of the Electric Power Research Institute as a project manager of studies relating to radiation control and decontamination.

OXIDATION AND RADIATION BUILDUP ON STAINLESS STEEL COMPONENTS OF BOILING WATER REACTORS

G. Romeo

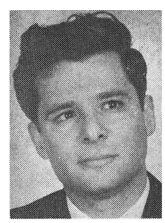


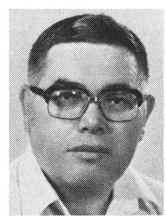
G. Romeo (Dr. Chem., University of Ferrara, Italy, 1965) has been with the General Electric Company, Nuclear Energy Division, working on the stability of UO_2-Zircaloy fuel and the buildup of radiation in boiling water reactors (BWRs). His current technical interests are concerned with the water chemistry of BWRs.

RADIOISOTOPES AND ISOTOPES

RESOLVING POWER OF DYNAMIC RADIATION GAUGES

Amos Notea
Yitzhak Segal



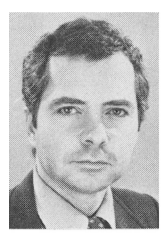


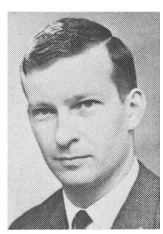
Amos Notea (top) (PhD, Hebrew University, Jerusalem) presently works in the area of radiation gauging techniques and interpretational models. **Yitzhak Segal** (D.Sc., nuclear science, Technion) is currently interested in research that includes modeling of measurement systems.

HEAT TRANSFER AND FLUID FLOW

SUMMARY OF DENTING MECHANISM AND KINETIC STUDIES WITH SEAWATER

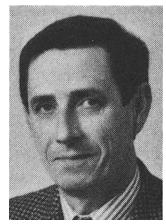
Jean-Louis Campan
Gérard Pinard-Legry
Alain J. Vignes





Jean-Louis Campan (top) (Engineer of the Ecole Supérieure d'Electricité, 1958) worked beginning in 1958 in the Fast Breeder Nuclear Physics Department of the Commissariat à l'Energie Atomique, first in Saclay, now at the Cadarache Nuclear Center. He is currently deputy to the water reactor technology service manager. His special responsibility is for the experimental work done on the large facilities. **Gérard Pinard-Legry** (bottom) (Engineer of the Ecole Nationale Supérieure de Chimie de Paris, 1961; Docteur ès Sciences Physiques, Université de Paris, 1969)

has been working since 1969 in the Corrosion Department of the Commissariat à l'Energie Atomique, Fontenay aux Roses. He is currently manager of the Section d'Etude de la Corrosion Aqueuse. **Alain J. Vignes** (right) (chemical engineer, Ecole Nationale Superieure des Industries Chimiques, 1957; PhD, chemical engineering, 1960; post-doctorate fellow, University of Delaware, 1962-1963) is currently Technical Director of the Manufacturing Division of Framatome. He was professor of metallurgy and director of the Materials Research Center of the School of Mines, Paris, France, from 1970 to 1975, and scientific advisor to the Technical Director of Framatome between 1976 and 1980.



LOW-PRESSURE TRANSIENT FLOW FILM BOILING IN VERTICALLY ORIENTED ROD BUNDLES

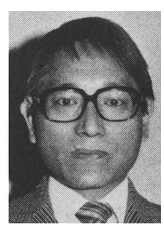
Guy G. Loomis
Rex W. Shumway

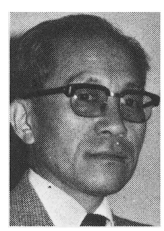
Guy G. Loomis (left) (BS, engineering physics, Texas Tech University, 1970; MS, nuclear engineering, University of New Mexico, 1972) is an engineering specialist with the Water Reactor Research Test Facility at the Idaho National Engineering Laboratory (INEL). Current research involves steam generator tube rupture and natural circulation in light water reactors. **Rex W. Shumway** (right) (BES, 1965, and MS, 1966, mechanical engineering, Brigham Young University; PhD, mechanical engineering, University of Arizona, 1969) is a principal engineer with the Code Development Division at INEL. Current studies are boiling water reactor heat transfer.

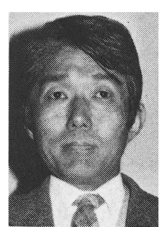
TECHNIQUES

DEVELOPMENT OF A SHIELDED ION MICROPROBE ANALYZER (SIMA) AND ITS APPLICATION TO FAST REACTOR FUEL ELEMENTS

Yuji Enokido
Sadamu Yamanouchi
Junji Komatsu
Toshiyuki Itaki



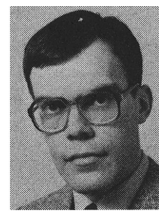


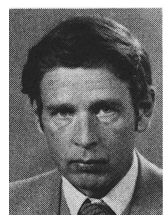


Yuji Enokido (top right) (MS, physical metallurgy, Nagoya University, 1969; Dr. Eng., mechanical engineering, Technical University Hannover, 1973) is an assistant senior engineer of the Power Reactor and Nuclear Fuel Development Corporation (PNC). His current technical interests are chemical and mechanical behavior of fast reactor fuel and cladding during irradiation. **Sadamu Yamanouchi** (top left) (BS, mechanical engineering, Kogakuin University, Tokyo, 1953) is responsible for the Alpha Gamma Facility (AGF) of PNC. After performing research in the Iron and Steel Department of the National Research Institute of Metals, he joined the Material Monitoring Facility (MMF) of PNC as a deputy manager. His current technical interests are electron microscopy and diffraction of improved stainless steel after irradiation. **Junji Komatsu** (bottom right) (BS, ceramics, Kyoto University, 1958) is currently a deputy director of the Plutonium Fuel Division of PNC. He has worked in the areas of postirradiation examination (PIE) and analysis and evaluation of fast reactor fuel since 1967. His current fields of interest include nuclear fuel behavior, properties, and fabrication. **Toshiyuki Itaki** (bottom left) (BS, metallurgy, Waseda University, Tokyo, 1955) has been engaged in plutonium fuel fabrication and its quality control at the Tokai Works of PNC since 1967. He is currently a director of the Fuel and Material Division of Oarai Engineering Center. He is interested in the study and evaluation of fuel performance in the fast reactor through PIE.

UNFOLDING TRIGA REACTOR NEUTRON SPECTRA FROM MULTICOMPONENT ACTIVATION DETECTOR DATA WITH LOUHI82

J. V. Sandberg
J. T. Routti



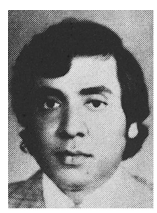


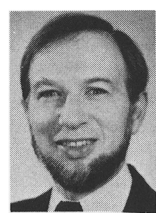
J. V. Sandberg (top) (MS, technical physics, 1977, and Lic. Techn., nuclear engineering, 1981, Helsinki University of Technology) has been working on spectrum unfolding, activation detectors, and hadron cascade simulations, previously at the European Organization for Nuclear Research (CERN) and currently at the Helsinki University of Technology. **J. T. Routti** (MS, technical physics, Helsinki University of Technology, 1964; MS, 1966, and PhD, 1969, nuclear engineering, University of California-Berkeley) has been working on gamma spectrum analysis, activation detectors, hadron cascade simulations, and radiation safety at Lawrence Berkeley Laboratory and at CERN. He has been professor of nuclear engineering in the Helsinki University of Technology since 1975. His current interests also include studies of energy policies, nuclear energy, and new energy systems.

FUEL CYCLES

RELATIVE WORTH OF ^{233}U AND ^{235}U IN LIGHT WATER REACTOR FUEL CYCLES

Ansar Parvez
Martin Becker



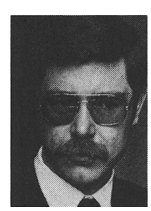


Ansar Parvez (top) [MSc, physics, Punjab University, Pakistan, 1969; MSc, nuclear technology, Quid-i-Azam University, Pakistan, 1971; PhD, nuclear engineering and science, Rensselaer Polytechnic Institute (RPI), 1977] is currently a visiting assistant professor at Purdue University on leave from the Pakistan Atomic Energy Commission. His areas of interest include core neutronics, fuel cycle analysis, nuclear fuel management, computer application, and interactive graphics computing. **Martin Becker** (BS, New York University, 1960; MS, 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 more than 180 publications. His current interests include reactor physics, mathematical methods, thermal-hydraulic stability, nuclear waste management, 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 other areas such as plant operating reliability, operator roles at power plants, nuclear fuel cycle analysis, and plant instrumentation.

HEAT TRANSFER AND FLUID FLOW

RADIATIVE HEAT TRANSFER IN A PRESSURIZED WATER REACTOR FUEL BUNDLE UNDER ACCIDENT CONDITIONS

Enrico Lorenzini
Pier Giacomo Sola
Marco Spiga



Enrico Lorenzini (right) (Dr. Eng., electronic engineering, Bologna University, 1965) is full professor at the University of Bologna (UB) and a member of the Engineering and Technological Committees of the National Research Council. His interest

is directed in heat transfer and energy problems, mainly referred to nuclear engineering. **Pier Giacomo Sola** (top) (Dr. Eng., nuclear engineering, Bologna University, 1982) has worked at risk assessment in the loss-of-coolant accident simulating Super-Sara Project, in the European Joint Research Center in Ispra. He is presently involved in the development of computerized procedures for event and fault trees. His current interests regard fast breeder reactor components reliability and data collection. **Marco Spiga** (bottom) (Dr. Eng., nuclear engineering, Bologna University, 1976) is presently employed as researcher at the UB. His activity is mainly focused in the area of heat transfer, prominently applied to the problems involving thermomechanical features and safety of nuclear plants.