# AUTHORS — FEBRUARY 1990

**FUEL CYCLES**

## ADVANCES IN TECHNOLOGY FOR STORING LIGHT WATER REACTOR SPENT FUEL

E. Robert Gilbert
Wendell J. Bailey
A. Burtron Johnson, Jr.
Mikal A. McKinnon

**E. Robert Gilbert** (top right) (BS, 1961; MS, 1962; and PhD, 1970, engineering science, Washington State University) is a staff scientist in the Department of Reactor Systems, Fuels, and Materials at Battelle Pacific Northwest Laboratories (PNL), where he also serves as leader of the fuel and materials performance group. He has experience in research on materials degradation, radiation effects, and analysis of nuclear fuel behavior in storage environments. **Wendell J. Bailey** (top left) (BS, mechanical engineering, 1950; BS, mathematics, 1951; MS, mechanical engineering, 1961, Oregon State University) is a staff scientist in the Department of Reactor Systems, Fuels, and Materials at PNL. He has experience in safety-related problems with nuclear fuel in commercial light water reactors (LWRs); evaluating the integrity of spent fuel in wet storage; developing, fabricating, irradiation testing, and evaluating plutonium- and uranium-bearing fuel elements; and developing design bases and criteria for $UO_2$ and $UO_2$-$PuO_2$ fuel design for commercial LWRs. **A. Burtron Johnson, Jr.** (bottom right) (PhD, fuel technology, University of Utah, 1958) has been on the PNL staff since 1965. He is currently a senior staff scientist. His principal research areas include effects of radiation on metal oxidation, Zircaloy-clad fuel behavior in wet and dry storage, ancient metal durability, and nuclear plant aging and license renewal. **Mikal A. McKinnon** (bottom left) (PhD, mechanical engineering, Utah State University, 1971) is a senior research engineer at PNL. Since 1983, he has managed the experimental and analytical thermal and shielding performance evaluation of four metal casks proposed for dry storage of spent nuclear fuel.
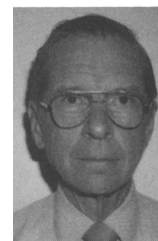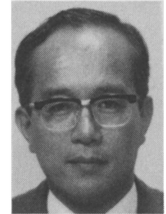
## CONSTRUCTION OF THE MONJU PROTOTYPE FAST BREEDER REACTOR

Tadao Takahashi
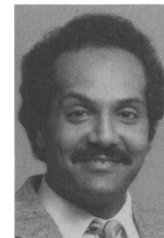Osamu Yamaguchi
Tetsuo Kobori

**Tadao Takahashi** (top) (MS, nuclear engineering, Tokyo Institute of Technology, Japan, 1962) is involved in the design and construction of the Monju fast breeder reactor (FBR). He is in charge of research and development (R&D) programs for FBRs and the Advanced Test Reactor. **Osamu Yamaguchi** (center) (BS, electrical engineering, University of Kyoto, Japan, 1960) has experience in the design and construction of a gas-cooled reactor and in the operation of a light water reactor for the Japan Atomic Power Company and the Fugen heavy water reactor for the Power Reactor and Nuclear Fuel Development Corporation. **Tetsuo Kobori** (bottom) (BS, mechanical engineering, Kyushu Institute of Technology, Japan, 1958) has experience in the design, construction, and operation of boiling water reactors and in R&D of the Fugen heavy water reactor. He has worked at the Monju construction site since April 1987.

## A COMPARISON OF RELAP5/MOD2 RESULTS TO THE DATA OF A SMALL-BREAK LOSS-OF-COOLANT ACCIDENT EXPERIMENT OF AN IAEA STANDARD PROBLEM EXERCISE
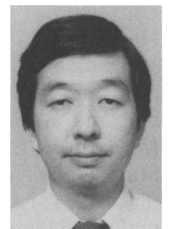
Sandra M. Sloan
Yassin A. Hassan

**Sandra M. Sloan** (top) [BS, nuclear engineering, Texas A&M University (Texas A&M), 1988] is a graduate student in nuclear engineering at Texas A&M. Her thesis is a study of RELAP5/MOD2 and RELAP5/MOD3 predictions of a small-break loss-of-coolant accident simulation conducted at the Rig of Safety Assessment IV Large-Scale Test Facility. She is the recipient of a U.S. Department of Energy nuclear engineering fellowship. **Yassin A. Hassan** (BS, nuclear engineering, University of Alexandria, Egypt, 1968; MS, nuclear engineering, University of Illinois, 1975; MS, mechanical engineering, University of Virginia, 1985; PhD, nuclear engineering, University of Illinois, 1979) is on the faculty of the Department of Nuclear Engineering at Texas A&M. He was previously with Babcock and Wilcox Company for 7 years. His interests include computational and experimental fluid flow, two-phase flows, and nuclear reactor safety.

## DEVELOPMENT OF THE SESAME METALLIC FUEL PERFORMANCE CODE

Tsuguyuki Kobayashi
Motoyasu Kinoshita
Sadao Hattori
Toru Ogawa
Yasushi Tsuboi
Masayoshi Ishida
Shinta Ogawa
Hiroaki Saito

**Tsuguyuki Kobayashi** (right) (MS, nuclear engineering, Tokyo Institute of Technology, Japan, 1978) is a senior researcher at the Central Research Institute of the Electric Power Industry (CRIEPI). He is in charge of fast breeder reactor (FBR) fuel design and related research and development (R&D). His main interest is the feasibility of the metallic fuel cycle. **Motoyasu Kinoshita** (left) (MS, engineering, Keio University, Japan, 1974)
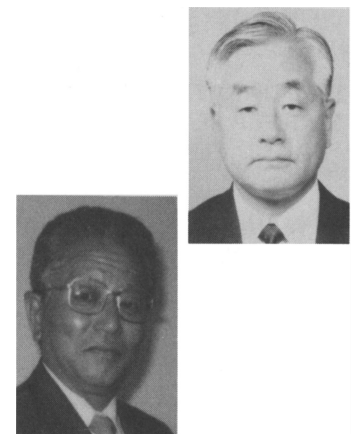
is a research fellow at CRIEPI. His interests include the irradiation performance of nuclear fuels and its modeling. **Sadao Hattori** (top right) (MS, nuclear engineering, Tokyo Institute of Technology, Japan, 1959; PhD, nuclear engineering, University of Tokyo, 1988) is vice president in charge of nuclear energy at CRIEPI. He has experience in the design, safety, and licensing of light water reactors (LWRs) for the Chubu Electric Power Company and in the design, licensing, and construction of the Fugen nuclear power plant for the Power Reactor and Nuclear Fuel Development Corporation. He was the director of the liquid-metal FBR research project at CRIEPI. **Toru Ogawa** (top left) (MS, nuclear engineering, Tohoku University, Japan, 1975; PhD, nuclear engineering, Osaka University, Japan, 1982) is a senior research scientist at the Japan Atomic Energy Research Institute. He is in charge of R&D of fuels for advanced reactors. His interests include application of thermochemistry to nuclear fuels engineering. **Yasushi Tsuboi** (center right) (MS, engineering science, Kyoto University, Japan, 1982) is an engineer in the Nuclear Engineering Division of Toshiba Corporation, where he is engaged in FBR fuel development. His main interest is in long-life fuel. **Masayoshi Ishida** (center left) (MS, physics, Tokyo Institute of Technology, Japan, 1969) is a senior researcher in the Hitachi, Ltd., Energy Research Laboratory, where he is responsible for fuel behavior modeling and reactor safety research for FBRs. **Shinta Ogawa** (bottom right) (BA, Seikei University, Japan, 1977) is engaged in LWR and FBR fuel performance analyses and design studies at Mitsubishi Atomic Power Industries. **Hiroaki Saito** (bottom left) (BS, mathematics, Nihon University, Japan, 1974) is a section manager at Century Research Center Corporation, where he works in fuel behavior analysis. His current technical interest is fuel behavior in new types of reactors.
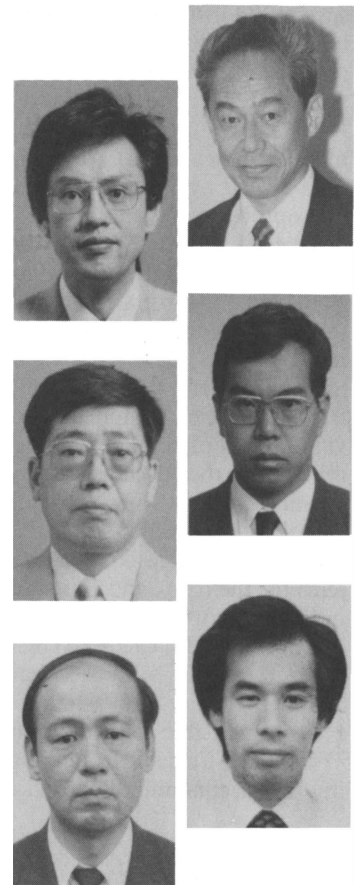
## PRESENT STATUS OF FAST BREEDER REACTOR FUEL CYCLE DEVELOPMENT AT PNC

*Masao Yamamoto*
*Ken-ichi Matsumoto*

**Masao Yamamoto** (top) (BS, chemistry, University of Kanazawa, Japan, 1955) has had experience in the nuclear fuel cycle, especially in reprocessing, mixed-oxide fabrication, and high-activity waste vitrification. He currently is deputy senior director of the Radioactive Waste Management Project at Power Reactor and Nuclear Fuel Development Corporation (PNC). **Ken-ichi Matsumoto** (BS, chemistry, University of Kyushu, Japan, 1957; graduate, IINSE, Argonne National Laboratory, 1964) has had experience in the refining of uranium metal, post-irradiation examination of nuclear fuels, fuel fabrication for the Joyo fast breeder reactor, and reprocessing of spent nuclear fuel. He is deputy director of Tokai Works of PNC and director of the Tokai Reprocessing Plant.

**RADIOACTIVE WASTE MANAGEMENT**

## A REMOTE CANISTER-POSITIONING AND GLASS LEVEL DETECTION SYSTEM

*Ronald W. Goles*
*Peter J. Hof*
*Richard D. Dierks*
*Langdon K. Holton, Jr.*

**Ronald W. Goles** (right) (BS, chemistry, University of Illinois, 1966; PhD, nuclear chemistry, Michigan State University, 1972) is a senior research scientist with Pacific Northwest Laboratory (PNL). His research in nuclear waste immobilization and long-term spent-fuel rod storage has led to the development of highly
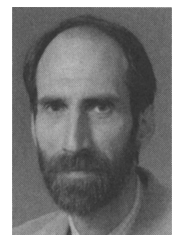
specialized instruments for environmental surveillance, source-term characterization, process control, and remote analysis. Currently, he is involved in supporting the design of effluent emission abatement systems for future waste solidification plants. **Peter J. Hof** (top) (AS, electronics engineering, Oregon Institute of Technology, 1967) is a senior technical specialist with PNL. He has had over 20 years' experience in developing embedded microprocessor-based systems. His areas of design and development work include hardware and firmware for data acquisition and control, portable and remote instrumentation, and robotics at the circuit, card, and systems levels. **Richard D. Dierks** (center) (BE, chemical engineering, University of Southern California, 1944) was a senior development engineer at PNL. From 1977 until his retirement in 1988, his efforts focused on utilizing electric glassmaking equipment for the continuous dehydration and vitrification of simulated nuclear waste slurries. This work culminated in the successful operation of a radioactive liquid-fed ceramic melter with a high-radiation-level aqueous waste slurry in PNL's large-scale radioactive engineering cell. From 1948 to 1977, he worked to develop process control instrumentation systems for the redox and Purex fuel recycling processes and for the uranium recovery waste recycling process. **Langdon K. Holton, Jr.** (bottom) (BS, chemical engineering, University of California, Berkeley, 1977; MS, chemical engineering, 1981, and MBA, 1986, University of Washington) is a staff engineer with PNL. He is responsible for radiochemical operations in PNL's Waste Technology Center. His interests include radiochemical engineering and decontamination and decommissioning.

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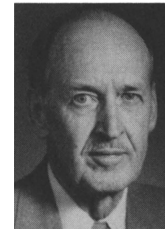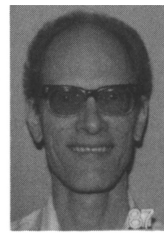
**HEAT TRANSFER AND FLUID FLOW**

## IDENTIFICATION OF TWO-PHASE FLOW PATTERNS IN A NUCLEAR REACTOR BY HIGH-FREQUENCY CONTRIBUTION FRACTION

Y. W. Wang
B. S. Pei
C. H. King
S. C. Lee

**Y. W. Wang** (top right) [BS, 1985, and MS, 1987, nuclear engineering, National Tsing-Hua University (NTHU), Taiwan] is a PhD student in the Department of Nuclear Engineering at NTHU. His research interests include two-phase flow and heat transfer, time-series and system analysis, and image processing. **B. S. Pei** (top left) (BS, nuclear engineering, NTHU, 1975; MS, 1980, and PhD, 1981, nuclear engineering, University of Cincinnati) is a professor in the Department of Nuclear Engineering at NTHU. His research interests include two-phase flow and heat transfer, reactor safety analysis, and severe core damage study. **C. H. King** (bottom right) (MS, 1978, and PhD, 1988, nuclear engineering, NTHU) is an associate research scientist in the Nuclear Engineering Division of the Institute of Nuclear Energy Research (INER) in Taiwan. His research interests include two-phase flow, neutron noise analysis, and system identification, and he currently concentrates on two-phase flow regime identification by neutron noise analysis. **S. C. Lee** (bottom left) (PhD, nuclear engineering, University of Michigan, 1984) is an associate research scientist in the Nuclear Engineering Division of INER. His research interests include two-phase flow instability and density wave oscillations, pressurized water reactor system modeling and simulation, optimal control and estimation, digital control, and related techniques.
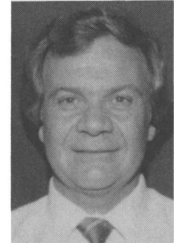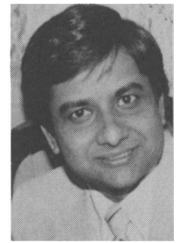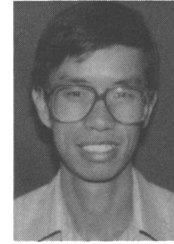
**A PROPOSED CALCULATIONAL MODEL FOR TWO-PHASE COUNTERCURRENT FLOW LIMITATION IN CHANNELS WITH ABRUPT AREA CHANGE**

*Tanvir Salim*
*Woon-Shing Yeung*
*R. Thomas Fernandez*

**Tanvir Salim** (top) (MS, energy engineering, University of Lowell, 1985) is with the Boston Edison Company, Department of Nuclear Engineering. His research interests involve the applications of thermal-hydraulic computer codes to reactor safety analyses. **Woon-Shing Yeung** (center) (PhD, mechanical engineering, University of California, Berkeley, 1979) has been on the mechanical engineering faculty at the University of Lowell since 1981. His areas of interest include computational methods, nuclear safety analyses, and fluid dynamics. **R. Thomas Fernandez** (bottom) (PhD, nuclear engineering, University of California, Berkeley, 1972) has been with the Yankee Atomic Electric Company, Department of Nuclear Engineering, since 1979. His areas of interest include thermal hydraulics, nuclear safety analyses, and advanced reactors.

**TECHNIQUES**

**AN INTELLIGENT STOCHASTIC OPTIMIZATION ROUTINE FOR NUCLEAR FUEL CYCLE DESIGN**

*Geoffrey Thomas Parks*

**Geoffrey Thomas Parks** (BA, 1984, and MA, 1987, engineering, and PhD, 1989, nuclear engineering, University of Cambridge, United Kingdom) is a research fellow at Jesus College, Cambridge, and a Central Electricity Generating Board visiting fellow. His current research interests include fuel cycle modeling and dynamics, Monte Carlo optimization techniques, and neutron stochastic theory.
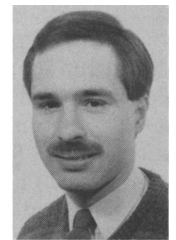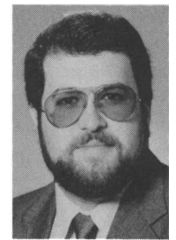
**IMAGE RECONSTRUCTION FOR A RADIATION FIELD MAPPING DEVICE**

*Robert Gould*
*Edward S. Kenney*

**Robert Gould** (top) [MS, nuclear engineering, The Pennsylvania State University (PSU) 1989] has been a graduate student in nuclear engineering at PSU since 1986. His research interests include gamma-ray and X-ray measurement, detection, and imaging, and instrumentation and control system design. **Edward S. Kenney** (PhD, physics, PSU, 1964) has been on the nuclear engineering faculty at PSU since 1964. His research interests include reactor and medical gamma-ray and X-ray measurement, detection, and imaging; reactor instrumentation and control; and the effects of radiation on semiconductor devices.

**EDUCATION**

**GPU NUCLEAR CORPORATION LICENSED OPERATOR REQUALIFICATION PROGRAM USING THE PENN STATE BREAZEALE NUCLEAR REACTOR**

*Samuel H. Levine*
*Terry L. Flinchbaugh*
*John L. Penkala*
*Daniel E. Hughes*
*Kenneth E. Rudy*
*Craig C. Faust*
*Ronald H. Maag*

**Samuel H. Levine** (right) (PhD, nuclear physics, University of Pittsburgh, 1954) is a professor of nuclear engineering at The Pennsylvania State University (PSU). His current technical interests are in fuel management, nuclear power operation,
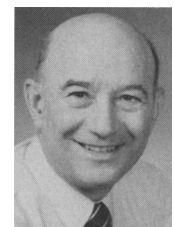
optimization techniques, beta dosimetry, reactor design, fast reactor physics, research reactor experiments, and neutron radiography. **Terry L. Flinchbaugh** (top right) (Assoc., manufacturing technology, PSU, 1967) has been on the Penn State Breazeale Reactor (PSBR) staff since 1967 and has been a licensed senior reactor operator since 1969. He currently serves as operations and training manager. **John L. Penkala** (top left) (BS, electrical engineering, PSU, 1965) was on the operating staff of the PSBR since 1959 and had been a PSU nuclear engineering faculty member since 1965 until his retirement in 1986. As training supervisor at the PSBR, he was in charge of foreign (International Atomic Energy Agency) and domestic (nuclear utilities) training programs, taught undergraduate and graduate nuclear engineering laboratories and reactor operations courses, and served as editor of the PSBR operating procedures manual. After his retirement, he did extensive consulting work for the American Council on Education in the area of college credit equivalency for reactor operations training programs offered by numerous nuclear utilities. **Daniel E. Hughes** (center right) (MS, nuclear engineering, PSU, 1986) is a research assistant at the PSBR, where he has held a senior reactor operator's license since 1984. His research interest is neutron radiography, and he is currently the project manager for the reactor control and instrumentation system upgrade. **Kenneth E. Rudy** (center left) (Assoc., technology, Williamsport Community College, 1960) has been a licensed reactor operator on the PSBR staff since 1968. As support services supervisor, he is in charge of the physical plant and the design and fabrication of equipment used for research. **Craig C. Faust** (bottom right) (BS, nuclear engineering technology) is the human performance evaluation system coordinator at Three Mile Island Unit 2 (TMI-2). He previously served as a licensed operator instructor and was involved in developing/revising training programs and administering operator training at TMI-2. He is an ex-navy nuclear propulsion operator and holds a senior reactor operator's license. His interests include event-specific error analysis and nuclear plant operation. **Ronald H. Maag** (bottom left) (BS, nuclear engineering technology) is the supervisor of licensed and nonlicensed operator training at the TMI Nuclear Generating Station. He is responsible for training program content and administrations for both units. He is an ex-navy nuclear propulsion operator and holds an active senior reactor operator's license on TMI-1. His interests include nuclear plant operations and training program design and development.