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METALS AND CERAMICS DIVISION PROGRESS REPORT FOR PERIOD ENDING JUNE 30, 1984

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EXECUTIVE SUMMARY

This progress report covers the research and development activities of the Metals and Ceramics Division from January 1, 1983, through June 30, 1984. In keeping with tradition, the format of the report follows rather closely the organizational structure of the division. Short summaries of technical work in progress in the various experimental groups are presented in six parts. Chapter 1 deals with the research and development activities of the Engineering Materials Section, Chap. 2 with the Processing Science and Technology Section, Chap. 3 with the Materials Science Section, Chap. 4 with Project Activities, Chap. 5 with Specialized Research Facilities and Equipment, and Chap. 6 with Miscellaneous Activities.

Persistence in our quest to strengthen materials research at elevated temperature has brought the proposed High-Temperature Materials Laboratory much closer to reality. Final design of the new facility is essentially complete, and funding to commence construction work in FY 1985 has been appropriated by Congress. The new materials laboratory, which has been designated a national research center, is designed to operate in user-dedicated mode. Furthermore, the thrust and direction of research will be oriented to accommodate both basic and applied work. When completed in 1987, the new facility will provide a gross floor area of 5992 m^2 (64,500 ft^2) for collaborative research with scientists from other research laboratories and with representatives from industry and academia.

Another noteworthy development that augurs well for technological advance on the local materials front is the permanent location of the American Welding Technology Application Center (AWTAC) in the Oak Ridge–Knoxville area. The center was established to promote the successful transfer of advanced joining technologies from the laboratory to industry and to serve as an exchange point for information generated in the field by industry, government agencies, universities, and technical associations. The AWTAC intends to draw on expertise at the University of Tennessee, Tennessee Valley Authority, and Oak Ridge National Laboratory (ORNL) to develop and apply advanced technology for the benefit of the industrial sector. Incidentally, the Metals and Ceramics Division Welding and Brazing Group, which was strongly instrumental in having AWTAC locate in the Oak Ridge area, recently obtained a Leybold-Heraeus electron beam welder. This unit of 15-kW capacity is capable of penetrating 50-mm-thick steel.

In March of this year, a unique contract was negotiated between Cabot Corporation and Union Carbide Nuclear Division to allow Cabot to pursue materials research at ORNL. The $400,000 agreement permits Cabot to hold the patent rights to any innovations resulting from research specified in the contract. Initially, the collaborative research effort will concentrate on the development of two kinds of corrosion-resistant alloys: a nickel-molybdenum alloy and a series of nickel-silicon alloys for application in hostile corrosive environments. The plan is that Cabot will support an additional $600,000 of ceramics research in the next fiscal year.

Laboratory and division management continues to explore alternative routes for dissemination of technical information to American industry. In particular, we seek to translate basic findings emanating in the laboratory into effective industrial applications. Among the various activities of this nature pursued in the past six months are

- A Technology Transfer Meeting on New Oxide Varistor Materials was held on January 11–12, 1984, to discuss recent developments at ORNL in the synthesis and processing of zinc oxide. These developments represent significant improvements in the manufacture and properties of varistors to protect high-voltage lines from destructive overloads.

- A joint ORNL–The Metallurgical Society of AIME Conference on High-Temperature Alloys: Theory and Design was held in Bethesda, Maryland, on April 9–11, 1984. The meeting provided a forum for reporting, reviewing, and discussing recent progress in solid state theory, materials science, and applied alloy design.

- The Eighth Semiannual Meeting of U.S. Department of Energy (DOE) Materials Directors was held at Lawrence Berkeley Laboratory on April 5–6, 1984. The meeting focused on rendering assistance to the automotive industry. The DOE directors will interact with the petrochemical industry at their fall meeting.

- Division staff members played a key role in organizing and reporting at the Conference on Materials for Future Energy Systems held in Washington, D.C., on May 1–3, 1984. The conference was sponsored by the American Society for Metals in cooperation with DOE, the National Materials Advisory Board, and the White House Office of Science and Technology Policy Committee. The role of materials in energy production was reviewed in context with a broad spectrum of energy sources; science and policy issues that affect materials science and engineering were discussed also.

- The fourth meeting sponsored by the Industrial Research Institute highlighting potential commercial applications of government-sponsored research and new technological developments was held in Oak Ridge on May 22–24, 1984. The three-day program focused particularly on materials science and materials technologies.

- Oak Ridge National Laboratory is one of two national laboratories working with the steel industry to make U.S. steel companies more competitive in the marketplace. A meeting was held in Oak Ridge on May 23, 1984, to identify critical problems and to discuss potential areas in which ORNL could make meaningful contributions.

Budget data and information on personnel and organizational structure are presented in Appendixes A through C. Data on Honors and Awards, Information Meeting and Advisory Committee, Publications, and Oral Presentations are presented in Appendixes D through H. Previous reports issued in this series are cited on the following page.

Reports previously issued in this series are as follows:

ORNL-28	Period Ending March 1, 1948
ORNL-69	Period Ending May 31, 1948
ORNL-407	Period Ending July 31, 1949
ORNL-511	Period Ending October 31, 1949
ORNL-583	Period Ending January 31, 1950
ORNL-754	Period Ending April 30, 1950
ORNL-827	Period Ending July 31, 1950
ORNL-910	Period Ending October 31, 1950
ORNL-987	Period Ending January 31, 1951
ORNL-1033	Period Ending April 30, 1951
ORNL-1108	Period Ending July 31, 1951
ORNL-1161	Period Ending October 31, 1951
ORNL-1267	Period Ending January 31, 1952
ORNL-1302	Period Ending April 30, 1952
ORNL-1363	Period Ending July 31, 1952
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ORNL-1503	Period Ending January 31, 1953
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ORNL-1625	Period Ending October 10, 1953
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ORNL-1875	Period Ending October 10, 1954
ORNL-1911	Period Ending April 10, 1955
ORNL-1988	Period Ending October 10, 1955
ORNL-2080	Period Ending April 10, 1956
ORNL-2217	Period Ending October 10, 1956
ORNL-2422	Period Ending October 10, 1957
ORNL-2632	Period Ending October 10, 1958
ORNL-2839	Period Ending September 1, 1959
ORNL-2988	Period Ending July 1, 1960
ORNL-3160	Period Ending May 31, 1961
ORNL-3313	Period Ending May 31, 1962
ORNL-3470	Period Ending May 31, 1963
ORNL-3670	Period Ending June 30, 1964
ORNL-3870	Period Ending June 30, 1965
ORNL-3970	Period Ending June 30, 1966
ORNL-4170	Period Ending June 30, 1967
ORNL-4370	Period Ending June 30, 1968
ORNL-4470	Period Ending June 30, 1969
ORNL-4570	Period Ending June 30, 1970
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ORNL-4870	Period Ending June 30, 1973

ORNL-4970	Period Ending June 30, 1974
ORNL-5579	October 1, 1978–June 30, 1979
ORNL-5670	Period Ending June 30, 1980
ORNL-5810	Period Ending June 30, 1981
ORNL-5943	Period Ending December 31, 1982

1. ENGINEERING MATERIALS

G. M. Slaughter

This section is responsible for determining and evaluating the suitability of engineering materials for use in various energy systems, for developing new alloys, and for determining and developing improved joining and nondestructive testing techniques to ensure the structural integrity of materials and components in specific applications. It comprises approximately 65 staff members, about 50% of whom are professionals. Research and development activities are carried out in five different laboratories, which bear the functional names Materials Compatibility, Mechanical Properties, Nondestructive Testing, Pressure Vessel Technology, and Welding and Brazing. Additionally, divisional support for the Heavy Section Steel Technology (HSST) program and the Space Nuclear Projects is administered through this section. Brief descriptions of work performed by and major accomplishments of these groups are presented.

1.1 MATERIALS COMPATIBILITY—J. H. DeVan

The Materials Compatibility Group conducts corrosion studies in direct support of fusion energy, fossil energy, waste management, fuel reprocessing, and gas-cooled reactor projects. During this reporting period, related corrosion studies were also conducted under subcontract to Lawrence Livermore National Laboratory and General Electric Company.

Activities under the fusion energy program deal with the corrosion behavior of potential heat transfer and tritium-breeding fluids. Our objective is to identify the mechanisms by which these fluids attack potential first-wall materials at 400 to 600°C. We completed a kinetic analysis of the mass transfer of type 316 stainless steel in thermally convective lithium and obtained initial results for the weight loss behavior of representative first-wall materials in the more aggressive lead-lithium environment. A preliminary investigation showed that the oxidation of vanadium alloys in high-temperature water was not severe.

Corrosion studies supporting the development of fossil energy resources are divided between two tasks: corrosion of current collector materials in molten carbonate fuel cells and mechanisms of abrasive wear. Under the former task, thermochemical calculations were completed to define equilibrium phase relationships in the Fe-$LiKCO_3$ and Cr-$LiKCO_3$ systems. The predicted phase relationships are being compared with experimental results obtained from reaction rate studies of stainless steel current collector materials in molten $LiKCO_3$. The second task, aimed at wear mechanisms, involves the modification of a scanning electron microscope to permit direct observation of impingement damage to selected metal substrates by particles of silicon carbide. The particles are injected into the microscope at controlled velocities and trajectories to impact within a region of a substrate, which is being continuously scanned. Both sulfidizing and oxidizing conditions can be induced over the substrate to provide additional data on corrosion-erosion interactions.

A long-standing corrosion program in support of the High-Temperature Gas-Cooled Reactor (HTGR) was phased out last September. During the reporting period, studies were completed on the decarburization of 2 1/4 Cr-1 Mo steel by HTGR-He and on the solid state reactions occurring between alloy 800 and graphite impregnated with B_4C.

The remainder of the group's project activities concerned corrosion problems in the areas of waste management, fast reactor fuel reprocessing, and adsorption refrigeration. In the first area we conducted a critical assessment of potential failure mechanisms for metallic containers that have been identified for containment of high-level waste. The results were provided to the Nuclear Regulatory Commission (NRC) to aid their performance evaluation of waste packages. In the area of reprocessing, demonstrations are being planned in the Breeder Reactor Engineering Test at Hanford. Our contribution in this area has been in the selection of corrosion-resistant materials for process equipment in the remotely operated facility. Lastly, we are assisting the Oak Ridge National Laboratory (ORNL) Energy Division in improving the efficiency of absorption refrigeration cycles by the development of more efficient absorbers and refrigerants. We are conducting corrosion tests to determine the best materials for use in these new systems.

During the past year we completed a "seed money" project to investigate the electrochemical etching of titanium alloy castings. We demonstrated that under some conditions it is possible to delineate the dendritic structures of such castings electrochemically, which standard chemical etchants are unable to do.

1.2 MECHANICAL PROPERTIES—C. R. Brinkman

The Mechanical Properties Group develops and analyzes data, qualifies new materials, and provides materials engineering support for ongoing national energy- and defense-related programs. During the past 18 months we received support from the following programs: breeder reactor, 40%; defense, 14%; gas-cooled reactor, 14%; fossil, 11%; conservation, 8%; fusion, 3%; and miscellaneous service, 10%. The overall effort on these programs was in characterizing the elastic, plastic, creep, and fatigue (uniaxial, biaxial, and crack growth) behavior of base metals, weldments, ceramics, and polymers. After statistical and parametric analyses of the data, we present them in a form useful to engineers or code developers for design.

Fast breeder reactor work continued efforts to obtain various mechanical properties such as long-term creep and fatigue data for types 304 and 316 stainless steel, alloy 718, 2 1/4 Cr-1 Mo steel, and modified 9 Cr-1 Mo steel. Increased effort is currently directed to characterization of cast and weld metals of austenitic stainless steel because of their complex microstructures in comparison with wrought materials. We continue to investigate the influence of combined stress and temperature on the subsequent mechanical properties of thin-wall type 316 stainless steel large-diameter prototypic piping containing welds. This work is based on differences in the microstructure between stressed and unstressed regions of long-term creep specimens and the degradation of room-temperature toughness properties by prolonged exposure to elevated temperatures. Biaxial fatigue tests continued at elevated temperature on several wrought metals, including 2 1/4 Cr-1 Mo and type 316 stainless steel. These tests included combinations of in-phase push-pull and torsional cyclic loading, with all tests conducted in strain control by use of a unique extensometer developed at ORNL.

Several domestic and foreign utilities, steel suppliers, and design organizations have shown considerable interest in the recent development of modified 9 Cr-1 Mo ferritic steel. This new structural material for use at elevated temperatures offers several advantages, including increased strength and chromium conservation, compared with some austenitic stainless steels. Two foreign (United Kingdom and Canada) and three domestic utilities and several foreign laboratories are cooperating in the evaluation of this material. American Society for Testing and Materials specifications for various product forms were obtained, including seamless tubing, pressure vessel plate, forged or rolled pipe flanges, and seamless pipe. Materials data were submitted to the American Society for Mechanical Engineers Code formulating bodies. Code approval for Sect. I was obtained, with Sect. VIII approval expected in the near future.

Numerous pages of material properties and behavior were prepared by our Data Analysis Center for entry into the *Nuclear Systems Materials Handbook* in support of breeder reactor development. This effort has received particular emphasis despite the apparent decreased national effort on large liquid metal breeder reactors.

Data development and analysis for the materials technology to design and license HTGR cogeneration and reformer systems emphasized obtaining information on mechanical properties, thermal stability, and behavior of wrought materials and weldments. Structural alloys under investigation included Hastelloy X, alloy 718, 2 1/4 Cr-1 Mo steel, alloy 800H, and several ceramic materials, including silicon dioxide and alumina.

Work continued in commercial casting characterization in support of fossil materials development. This effort included mechanical property (creep, tensile, and impact) and microstructural characterization, including modified 9 Cr-1 Mo steel, CF8 and CF8M stainless steels, and 2 1/4 Cr-1 Mo steel. Castings were obtained from two domestic and one foreign sources.

Surface gasification project-supported work focused on the development of high-strength low-alloy steels for construction of gasifier pressure vessels. A small commercial heat of a new 3% Cr-1.5% Mo-V steel was procured, and research was started to determine the fabricability, strength, and toughness. Industrial participants in the task included AMAX, CarTech, Lukens Steel, Combustion Engineering, and Chicago Bridge and Iron. Work for the Fossil Energy Advanced Research and Technology Development Program was directed to providing services to the various university participants. Here, ORNL procured and distributed reference steels, weldments, and overlay claddings to the participants and, in some instances, performed heat-treating and various types of characterization tests. The following subcontractors were assisted: University of California, Berkeley; University of California, Santa Barbara; Cornell University; University of Illinois; Pennsylvania State University; and University of Tennessee.

We continued work on a conservation program to develop a high-voltage gas-cooled transformer. Our objective is to develop mechanical properties of candidate polymers and to investigate long-term degradation in the presence of anticipated transformer materials in SF_6 at temperatures up to about 100°C. This work will supplement efforts of others to establish (1) the optimum polymer for use in sheet-wound transformers and shunt reactors and (2) the compatibility of proposed materials of construction. Efforts were aimed at obtaining low-temperature creep properties on several polymers tested in various environments.

1.3 NONDESTRUCTIVE TESTING—R. W. McClung

The Nondestructive Testing Group develops new or improved methods of nondestructive testing (NDT) and provides technical support for nondestructive examination. The activities range from long-term studies of physical mechanisms and theory for development of advanced techniques and equipment to near-term development and technical support for various applied programs. The effort is broad based in terms of both the technologies involved (including penetrating radiation, eddy-current, ultrasonic, thermal, and penetrant techniques) and the varied interests of sponsoring agencies, especially those of the Department of Energy (DOE) and the NRC.

The major activity for DOE has been on the breeder reactor program. Ultrasonic signal processing techniques were investigated for improved flaw characterization in steel welds. Eddy-current studies emphasizing multiparameter multifrequency techniques, a special computer-controlled scanner, and modular instrumentation are planned for use on welds following initial studies on stainless steel plate. For the Clinch River Breeder Reactor (CRBR) steam generator, we provided technical support for ultrasonic techniques and equipment for in-service inspection (ISI) of the tubing and completed a report on development of eddy-current techniques for ISI of the tubing. Work was completed on the refurbishment of four production microfocus rod-anode X-ray units for use by the Westinghouse Nuclear Components Division (W-NCD) for its manufacturing examination of the CRBR steam generators.

Development and technical support were provided for both ultrasonic and eddy-current ISI techniques for double-wall tubing for a Westinghouse alternative steam generator design. Technical support to W-NCD for training for the operation of a microfocus rod-anode X-ray unit for radiography of tube-to-tubesheet joints was also provided. Other DOE nuclear work included low-voltage radiographic studies on graphite oxidation for the gas-cooled program.

For the DOE Office of Fusion Energy, we developed multifrequency eddy-current techniques and equipment for examining JBK-75 seam welds for the sheath of superconductor cable as part of the Large Coil Program. We also provided technical support for on-line computer-based eddy-current equipment installed at Airco for its use in examining the sheath seam weld of the superconductor to be fabricated into a large coil by Westinghouse. For the DOE Division of Energy Storage Systems, we applied advanced ultrasonic techniques that we developed for evaluating properties of fiber-reinforced plastic composite flywheels at intervals after spin testing. For the DOE Office of Space Nuclear Propulsion, we conducted feasibility studies and initial technique development in ultrasonics and radiography for examination of miniature thermoelectric devices for extraterrestrial space probes and provided technical support for examining alloys and graphite components for space nuclear systems.

Brief studies and applications of NDT to various ceramic materials and components were made for several DOE programs.

Technical consultation and support were provided to the program management staff for the fossil energy materials development program and for an analysis of spent fuel element casks. Initial studies were begun on electroslag castings for the fossil energy program. Technical assistance in multifrequency eddy-current instrumentation and technology was provided to several DOE weapons laboratories.

A major activity for NRC reactor safety research was development and improvement of multiparameter multifrequency eddy-current techniques for the ISI of light-water reactor steam generators. Another activity was interaction with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code committees for ultrasonic and radiographic techniques. We also provided consultation to the regulatory office in evaluating nondestructive examinations on commercial nuclear reactors.

Several items of "work for others" included fabrication of prototype multifrequency instruments for three requesters and eddy-current feasibility studies for electrical conductivity measurements on thin coatings for an Army laboratory.

1.4 PRESSURE VESSEL TECHNOLOGY—R. K. Nanstad

The Pressure Vessel Technology Group investigates the fracture resistance of structural materials, particularly steels for pressure vessel applications. This requires expertise in experimental fracture mechanics and metallurgy. Programs are sponsored by both NRC and DOE. We are currently emphasizing the materials property needs for the HSST, fossil energy materials, HTGR, magnetic fusion energy, and space reactor programs.

Fracture toughness testing of prestressed concrete reactor vessel (PCRV) liner and penetration steels was completed with the examination of weldments and with particular emphasis on dynamic and crack arrest fracture toughness during FY 1983. We analyzed that information to apply candidate PCRV liner steels and weldments to a reference fracture toughness framework in Appendix G of the *ASME Boiler and Pressure Vessel Code.* A draft report was prepared and will be published following final review. We have initiated a program to study elevated-temperature fracture toughness of structural materials for the HTGR.

Under the HSST thermal shock program, material property data were obtained for thermal shock experiment 7 (TSE-7) and pressurized thermal shock experiment 1 (PTSE-1). Investigations are continuing on lower bound fracture toughness, with the ultimate goal of prediction of thick-section component fracture toughness with small laboratory test specimens.

A new program to investigate effects of stainless steel cladding on flaw propagation in light-water reactors began in December 1981. The program was motivated by the possible consequences of thermal shocks in pressurized-water reactors (PWRs) and now includes the study of irradiation effects on cladding. The initial laboratory phase involved four-point bend testing of plates (914 × 406 × 51 mm) clad on one face with types 308 and 309 stainless steel. The initial results indicate that, at a toughness level that may exist in long-time operating PWRs, the unirradiated stainless steel has a limited capacity to arrest the extension of a dynamic flaw. The testing program is continuing and includes procurement of plates clad by a commercial fabricator by use of the three-wire series arc process. Phase I of the stainless steel cladding irradiation program (seventh HSST irradiation series) was completed with the irradiation and testing of Charpy V-notch and tensile specimens fabricated from a single-wire submerged arc cladding of types 309 and 308 stainless steel. The cladding irradiation program will continue in FY 1985 with the irradiation of specimens from the three-wire series arc material.

The fourth HSST irradiation experiment was started at the Bulk Shielding Reactor in December 1979. The experiment consists of four capsules containing Charpy impact, tensile, and 25-mm compact specimens. The materials are HSST plate 02 (A 533, grade B, class 1, steel) for reference purposes, four current-practice submerged arc welds with copper contents from 0.04 to 0.12%, and low upper-shelf material from the Federal Republic of Germany. Capsule irradiations were completed in July 1982. Charpy V-notch and tensile testing was completed, and fracture toughness testing is scheduled for completion by the end of FY 1984.

A new HSST irradiation project was initiated to examine the upward temperature shift of the K_{Ic} and K_{Ia} curves in the ASME Code. The project includes irradiated compact specimens up to 102 mm thick and unirradiated specimens up to 204 mm thick. Irradiations being performed in the Oak Ridge Research Reactor began in May 1984.

Studies on the Fossil Energy Materials Program have emphasized mechanical property characterization of 2 1/4 Cr-1 Mo and 3% Cr–1.5% Mo–V steels for gasification pressure vessels. Tensile properties and Charpy V-notch impact toughness were determined over a wide temperature range for various heats, with specific interest in the high-strength classes of both steels. The materials have been postweld heat treated (PWHT) for varying times to determine the effects of extended PWHT times on mechanical properties.

A substantial amount of testing with subsize Charpy impact specimens of ferritic first-wall materials for the Magnetic Fusion Energy Program was completed. A new automated impact machine was installed in the hot cell; testing of irradiated specimens began in June 1984.

A program to fabricate T-111 refractory alloy tubing for the Space Nuclear Materials Program was initiated, and the seed money–funded effort to investigate plastic zone formation continued.

1.5 WELDING AND BRAZING—S. A. David

The Welding and Brazing Group continues to conduct materials joining research and development for basic energy sciences, fossil energy, conservation, gas-cooled reactor, fast breeder reactor, and Navy projects.

The basic energy sciences welding study continued to investigate the solidification and phase stability of austenitic stainless steels and ferritic steels. Significant contributions were made toward understanding the solidification behavior and phase stability of austenitic stainless steel welds and the mechanism by which controlled residual element (CRE) additions improve the creep strength and ductility of stainless steel welds. For austenitic stainless steel welds containing CRE additions, we propose that the elimination of a continuous network of carbides is responsible for the improved elevated-temperature properties.

The fossil energy program emphasizes the development of welding consumables and characterization of their deposit properties for heavy-section weldments in the 3% Cr–1.5% Mo–V alloy for large-scale coal conversion vessels. Filler wire for submerged arc welding and coated electrodes for shielded metal arc welding are being developed and evaluated. Successful welds with acceptable mechanical properties were achieved for the shielded metal arc welding process. Jointly with the conservation program, activities are also under way to evaluate the weldability of ductile aluminides. The Ni,Fe aluminide has sometimes been prone to cracking during welding. Efforts are under way to identify the cracking mechanism and to develop procedures to weld this alloy successfully.

The conservation program activities center around improving the efficiency of automotive heat engines and thereby conserving fuel costs. Acceptable ceramic-to-metal joints are being developed for this application. A novel technique was developed to braze partially stabilized zirconia to nodular cast iron by a direct brazing technique or by brazing with a transition piece.

The gas-cooled reactor program aims at the development of internal bore welding techniques for superheater tube-to-tubesheet welds. High-quality weldments are required between a weld-clad alloy 800H forging and alloy 800H superheater tubing with a relatively heavy wall thickness. A versatile internal bore welding head was designed and fabricated for the welding development program.

The breeder reactor program in the past has demonstrated commercialization of CRE stainless steel filler metals and continues to study the weldability of modified 9 Cr-1 Mo alloy.

2. PROCESSING SCIENCE AND TECHNOLOGY

J. O. Stiegler

The Processing Science and Technology Section aims at exploiting processing variables to control microstructures and thereby properties of metallic and ceramic materials. Emphasis is primarily on materials for high-temperature applications, and groups in the section play a key role in the High-Temperature Materials Program at Oak Ridge National Laboratory (ORNL).

During the reporting period, several developments strengthened our position. Our development of ductile intermetallic alloys based on the composition Ni_3Al attracted wide interest from the industrial community. We recently entered into joint agreements with several producers to develop a capability for producing heats of these alloys by commercial practices. Within a few months we hope to have significant quantities of these materials under evaluation by industrial organizations. This fall we will hold a workshop for producers to evaluate progress toward commercial production of the alloys, and in the spring of 1985 we will hold a technology transfer meeting to acquaint potential users of the materials with their properties and capabilities.

We recently signed a contract with the Cabot Corporation to conduct research on several ordered alloy systems of interest to Cabot. We expect to expand that effort during the coming year to include other materials.

We initiated work on several paths to produce ceramic matrix composites combining both high-strength and high-fracture toughness. The room-temperature fracture toughness of alumina was shown to be doubled by the incorporation of about 20 vol % silicon carbide whiskers. The flexural strength, which was also increased substantially, showed little decline out to 1000°C. Composites were also produced by infiltration of fibrous preform by chemical vapor deposition or by the simultaneous deposition of two phases.

Members of the section are involved in both the management and research areas of the conservation programs on Ceramic Technology for Advanced Heat Engines and Materials for Energy Conversion and Utilization Technology and of the Fossil Energy Materials Program. In-house work, which comprises about one-third of the funding, includes efforts on development of toughened ceramics, joining, environmental effects, coating technology, and alloy development. In addition to subcontracting about two-thirds of the funding, management activities include close coordination with a sister program on Ceramic Technology sponsored by the National Aeronautics and Space Administration.

2.1 ALLOYING BEHAVIOR AND DESIGN—C. T. Liu

The primary goal of the Alloying Behavior and Design Group is developing and understanding the principles of alloying behavior and of structure-property relationships and their application to the creation of new materials to meet energy technology needs. The group focuses on three major programs: (1) high-temperature alloy design and development, (2) deformation and fracture of high-temperature materials, and (3) metastable materials and processing development. The three programs are closely related, with emphasis on design of new high-temperature structural materials by control of alloy composition, microstructure, and processing techniques.

The alloy design program is concerned with understanding and developing new structural materials based on ordered intermetallic alloys. Many ordered intermetallics possess attractive high-temperature properties; however, low ductility and brittle fracture restrict their use for structural applications. Both macroalloying and microalloying processes were used to improve the ductility and fabricability of several intermetallic alloy systems. Macroalloying is aimed at controlling ordered crystal and bulk properties in $(Fe,Co,Ni)_3V$, $Ni_3(Al,V)$, Fe_3Al, and Ni_3Si alloys, whereas microalloying is directed to alleviating both intrinsic and extrinsic grain-boundary weakness in nickel aluminides based on Ni_3Al. The significant achievement this year was the understanding of ductilizing effects of boron additions and the development of advanced nickel aluminides. The ductility of polycrystalline Ni_3Al can be dramatically improved by adding a few hundred parts per million of boron, which tends to segregate strongly to grain boundaries and enhances grain-boundary cohesion. Alloy stoichiometry strongly influences the intensity of boron segregation and the amount of grain-boundary aluminum, which, in turn, affect the fracture behavior and overall ductility of boron-doped Ni_3Al. The mechanical and metallurgical properties of boron-doped Ni_3Al and $(Ni,Fe)_3(Al,Fe)$ can be further improved by hafnium and zirconium additions at levels of less than 2 at. %. Aluminum additions substantially improve the high-temperature strength and corrosion resistance of long-range ordered alloys based on $(Fe,Co,Ni)_3V$. These ordered intermetallic alloys, with a combination of good ductility, low density, high-temperature strength, and oxidation resistance, constitute a new class of structural materials for potential uses at elevated temperatures.

The goal of the deformation and fracture program is understanding the mechanisms of deformation and fracture of structural alloys at elevated temperatures. The model alloy systems used included Ni–20% Cr (for nickel-base superalloys), Fe-Cr-Ni alloy (for austenitic stainless steels), and Ni_3Al-base alloys (for high-temperature aluminide alloys). Both experimental and theoretical approaches are used to investigate the effects of impurities on grain-boundary cavitation. Effects of trace elements on grain-boundary cavitation under creep and fatigue test conditions are studied by Auger spectroscopy. The 30-m Small-Angle Neutron Scattering (SANS) Facility is employed to obtain data on the nucleation and growth of grain-boundary cavities during deformation. The 1-MV high-voltage electron microscope is used to provide direct microstructural information to aid the SANS study. Quantitative measurements are made of grain-boundary sliding and grain-boundary diffusion. Recent theoretical modeling progress includes thermodynamics of solute segregation; a two-component cavity nucleation model; a time-dependent cavity nucleation model; and kinetics of solute segregation, stress concentration, and cavity stability.

The current emphasis of the metastable materials program is on structure-property relationships in metastable materials prepared by rapid quenching from the liquid or vapor states. Low-temperature specific heat measurements of liquid-quenched zirconium-nickel glass revealed the occurrence, in some compositions, of two separate superconducting transitions, indicating the presence of two glass phases. Compositional variations of the transition temperature and other physical properties derived from differential scanning calorimetry of crystallization indicated that the two phases arise from short-range structures characteristic of the glass at two specific compositions, 60 and 66.7 at. % Zr. Efforts to understand annealing embrittlement in $Fe_{80}B_{16}Si_2C_2$ melt-spun metallic glass ribbons involved Auger studies of fracture surfaces of as-quenched and annealed ribbons. The results indicate that embrittlement involves phase separation and the development of an inhomogeneous distribution of oxygen. Addition of small amounts (~100 at. ppm) of cerium to decrease the mobility of oxygen slowed annealing embrittlement significantly. Microadditions of cerium also affect strongly the magnetic properties of as-quenched ribbons. The results on both zirconium-nickel and $Fe_{80}B_{16}Si_2C_2$ metallic glasses indicate the importance of the medium-range structure of the glass in determining its properties and suggest that microalloying to control the distribution of trace impurities can significantly affect both structure and properties.

2.2 CERAMIC TECHNOLOGY—A. J. Moorhead

We have initiated some very important work on the development and characterization of SiC-whisker-reinforced oxide matrix composites for improved mechanical performance. These whiskers, produced from rice hulls, are only about 50 μm in length and 0.5 μm in diameter, allowing them to be incorporated into a composite by standard powder processing techniques. Most of the work has dealt with alumina as the matrix because it was deemed a promising material in an initial study. However, other matrix materials are also being explored as a way to tailor the composite for specific applications. Our approach is, first, to use hot pressing to identify compositions that exhibit improved tougheness and then to explore pressureless sintering for fabrication of near-net-shape pieces. At this early stage of development, our Al_2O_3–20 vol % SiC whisker composite has a fracture toughness K_{Ic} of 8.5 $MPa \cdot m^{1/2}$ and a room-temperature flexural strength of 650 MPa. Flexural strength at 1000°C is greater than 550 MPa. This material also has excellent slow crack growth behavior. Our current efforts are aimed at altering the bond between the whiskers and alumina matrix to maximize the energy absorbed at that interface during crack propagation, thereby resulting in further increases in K_{Ic}.

Research continues on the development and characterization of very fine-grained ZnO varistors. The sol-gel process was used to synthesize highly active powders that can be densified at low temperatures (800°C). Varistors having breakdown fields as high as 4000 V/mm have been prepared in this way. Ongoing studies of their electrical and thermal properties will relate these properties to microstructural and process variables.

The sodium-sulfur battery is a candidate for application to electric vehicles and utility load leveling. The electrolyte in this battery, β-alumina, often fails by fracture, which in many cases is initiated by electrolytic degradation. Furthermore, the conductivity of the electrolyte is very low at the operating temperature of some advanced cells. We have initiated research to (1) explore other compositions that promise better low-temperature conductivity and (2) examine ways in which to improve the toughness of the electrolyte and to minimize degradation and premature failure.

Silicon carbide (SiC) is a candidate material for both heat engine and recuperator components. Our efforts to develop a process for synthesis of high-purity ultrafine sinterable SiC powder continued during this reporting period. We also made considerable progress in the development of an SiC matrix composite to increase the reliability of this structural ceramic.

Silicon carbide powders were synthesized with the inexpensive and easily processed raw materials carbon black and mineral silica. High specific surface areas (10–20 m^2/g) were obtained; these areas are equivalent to those previously obtained with fumed silica and pitch or phenolic resin as the powder precursors and to commercially available SiC powders. A powder-processing procedure adaptable to industrial scaleup was developed for this material.

Composites of SiC and TiC hot pressed with carbon and aluminum additions exhibit room-temperature strength and fracture toughness values up to about 50% higher than that of the base SiC matrix. High-temperature strength for the SiC-TiC composite is also good. At 1000°C this material retains about 90% of its room-temperature strength, whereas the base SiC retains only about 45% of its room-temperature strength. At 1200°C the strength of the SiC-TiC composite declines to about 65% of the room-temperature value; this decline in strength is believed to be due to oxidation of the TiC particles, which introduces flaws into the surface of the composite. It has been shown that this oxidation is self-limiting; that is, after the surface TiC grains have been oxidized, no further oxidation occurs.

The carbon-bonded carbon-fiber (CBCF) insulation team has developmental efforts under way to identify and characterize a new source of rayon fiber, to evaluate fibers from more isotropic precursors such as phenolics, and to establish more definitive process controls for the new raw materials. The molding equipment was automated and instrumented to control and monitor the slurrying and molding operations. A new source of carbonized rayon fibers was identified and partially evaluated. Only thermal conductivity measurements are required to certify the new fiber for future CBCF insulation production. Three different isotropic fibers (all phenolic) are being evaluated for comparison of their graphitizing potential with that of the fibers from the rayon precursor.

Fracture mechanics studies of graphite have been very useful in understanding how fabrication variables influence mechanical behavior under service conditions. The critical defects in various graphites were identified, and the effects of processing, oxidation, and irradiation in altering the critical defect size were determined. Irradiation reduces the defect size as the density increases; however, the strain energy release rate was reduced as differential anisotropic growth increased the number of much smaller boundary defects. The overall result is that fracture toughness of irradiated graphite does not increase even though the strength is doubled by irradiation. Fracture toughness is also independent of preferred orientation, even for those graphites having strength ratios greater than 1.5. The significant difference in strength is due to the preferred orientation in defect size. We also showed that the sensitivity to strength loss by disparate flaws could be reduced by the addition of a fine microcracked structure that permits a significant growth in the initial defect before stable crack growth occurs. We are actively engaged in implementing these results in two cooperative development programs with graphite manufacturers to produce significantly improved graphites.

The high hardness and toughness of titanium diboride (TiB_2) ceramic make this material an attractive candidate for armor and other applications. An ORNL-developed process that uses nickel as a hot-pressing aid lowers the hot-pressing temperature required to prepare high-density bodies from 2000 to 1550°C. This development lowers the fabrication cost but, more important, results in improved properties, particularly the high toughness needed for armor applications. We successfully developed a modified procedure for hot pressing TiB_2 in an inert atmosphere and transferred this technology to two industrial fabricators. Each prepared five 15.24 × 15.24 × 2.54 cm tiles that are awaiting ballistics testing. An even larger scaleup is in process to prepare 25.4 × 25.4 × 5.1 cm tiles. In conjunction with this development, we are studying the effect of various processing variables on the hardness, fracture toughness, and flexural strength of this material.

Our research on the development of brazing filler metals that will wet and bond directly to structural ceramics and metals for high-performance applications at elevated temperatures, at high stress levels, and in oxidizing environments has continued. The wetting of a ceramic matrix by a metallic brazing filler metal and the extent and strength of a bond between the two are affected by a number of complex interrelated factors, including those of a chemical, mechanical, or geometric nature.

During this report period we continued the sessile drop wettability studies on substrates of Coors AD-99 and AD-998 alumina, DeGussit AL-23 alumina, and NiL.n MgO-stabilized partially stabilized zirconia. The room-temperature shear strength of the bond between many brazing filler metal sessile drops and ceramic substrates was measured. With several combinations of filler metal and ceramic, we found shear strengths greater than 100 MPa. We also had some of our experimental brazing filler metals fabricated into narrow foil strips by melt spinning and produced bend bar specimens by preplacing these foils in the joint between two ceramic coupons. Both room- and elevated-temperature (up to 400°C) flexural strength tests were conducted.

2.3 COATINGS AND TRIBOLOGY—W. J. Lackey

This group has completed a transition from mostly nuclear-fuels-related activities to mostly non-nuclear tasks involving coatings and tribology. Emphasis is on chemical vapor deposition (CVD) of coatings for fossil, heat engine, cutting tool, and low-friction wear-resistant materials in general. During this reporting period, we achieved particular success in depositing wear-resistant TiB_2, preparation of fiber-reinforced ceramic composites by chemical vapor infiltration, and deposition of a dispersoid-type SiC matrix composite. The major goal of the tribology effort is to understand the mechanisms of wear of ceramics, including thermochemical considerations.

Erosion-resistant coatings of TiB_2 prepared by CVD were investigated for use in highly erosive environments such as coal liquefaction plants. Properly deposited coatings exhibited little or no erosion during accelerated testing with a coal-oil slurry. Deposition temperature was the most important process variable affecting the coating performance. Coatings that were deposited at 900°C and exhibited very low erosion rates had low chlorine content (<0.5 wt %) and high Knoop microhardness (33 GPa). Coatings that were deposited at 800°C and exhibited high erosion rates had higher chlorine content (~6 wt %) and lower microhardness (15 GPa).

Ceramic fiber–ceramic matrix composites are receiving increased interest because of their higher strength and toughness. However, the high temperatures and pressures frequently encountered in conventional ceramic fabrication tend to damage the fibers. Thus, the objective of this work is to form the ceramic matrix by a practical low-stress low-temperature CVD infiltration process that will not damage the high strength ceramic fibers. Low-to-medium-density ceramic fiber (15–50 vol % fibers) preforms were prepared either by stacking layers of SiC cloth or by a vacuum-forming technique with a slurry of chopped SiC fibers and an SiC-type binder. The preforms of SiC fibers were then infiltrated with either CVD Si_3N_4 or SiC to form the ceramic matrix by use of a new approach that combines the advantages of a thermal gradient and a gas flow-through scheme to reduce infiltration times to hours. Process feasibility was established for infiltrating disks, and a system for infiltrating tubes was conceived. Densities as high as 93% of theoretical were achieved for small samples. Although the process is not optimized and current strengths (150 MPa) are not yet as high as desired, specimens have exhibited the desired ability to carry a load after crack initiation.

Toughened SiC-$TiSi_2$ dispersoid-type composites were produced by the simultaneous CVD of two phases. Fracture toughness values were nearly double the value of SiC when CH_3SiCl_3 and $TiCl_4$ vapors were used to produce the composites. Other systems consisting of SiC and the metal or metal carbides of Ni, Cr, W, and Mo were examined. Equilibrium thermochemical analyses of these systems were performed as a function of the CVD variables: temperature, total pressure, and reactant concentration.

A system is being developed for the plasma-activated CVD of extremely hard cubic boron nitride coatings. A stable argon plasma was produced by use of a radio-frequency generator; however, small flows of coating gases extinguished the plasma. Therefore, a commercial plasma torch is being purchased to optimize the amount of energy transferred from the generator to the plasma.

Stabilized zirconia coatings applied by CVD are being developed to provide thermal, wear, oxidation, and corrosion protection to a variety of advanced heat engine components. Experimental runs produced high-quality monoclinic ZrO_2 powder with no noticeable contaminants. Unfortunately, the reaction produced homogeneous nucleation within the gas phase instead of heterogeneous nucleation on the substrate.

An effort was recently undertaken to investigate the poor adherence of stabilized ZrO_2 coatings to metallic substrates. We are investigating the effect of ion mixing zirconium ions into the surface of the metallic substrate to promote better adherence. Numerous ion-mixed samples are being coated with stabilized zirconia at various locations, and adherence testing will be performed later.

Tribological studies of refractory materials has become an additional function of the group. A tribology laboratory being developed for wear testing at present includes a controlled scratch device and a pin-on-disc sliding wear system. Chemical effects in wear are also under study, and for this purpose a controlled atmosphere glove box and test chamber were made operative.

The pin-on-disc system was used to study the sliding wear mechanism of nickel-bonded TiB_2. The wear path failed by the disintergration of individual surface grains. Transmission electron microscopy showed a high concentration of dislocations in the subsurface region beneath the wear track and led to the accumulation of strain and failure of individual grains by reduction to fine particles.

Unlubricated pin-on-disc tests were also performed with five ceramics in nitrogen at room temperature and 205 and 425°C, sliding against themselves and each of the other sample types. The test ceramics were alumina, a zirconia-toughened alumina, silicon carbide, silicon nitride, and partially stabilized zirconia. In general, a highly deformed interfacial debris was present on severely worn surfaces, and the friction coefficients for the tests ranged from 0.7 to 1.0. Tests in partially stabilized zirconia at lower loads yielded minimal damage. Scanning electron microscopy and transmission electron microscopy study of the less severely worn zirconia samples showed the formation of fine surface fissures, a predominance of the cubic and monoclinic phases, and no evidence of dislocation formation. Further studies are in progress to amplify these observations.

Grouts used for disposal of nuclear wastes by hydrofracture are being characterized to verify that radionuclides have not migrated into the shale repository. Autoradiographs of cored grout samples showed no detectable migration. Isolation of the various cement phases revealed that the radionuclides cesium and strontium were adsorbed by the clay additives but not by the cement phases. A sample of grout was taken during an actual injection; its hydration was retarded several days because of boron present in the waste

2.4 METALS PROCESSING—R. L. Heestand

Activities in support of space and terrestrial power systems continued on fabricating iridium containment for general purpose heat sources through September 1983, when sufficient material was completed for projected use. The production task was then put in a standby condition, and a program on iridium process improvement was initiated to address casting iridium by consumable arc melting and to investigate a fabrication schedule modified to reduce delamination defects.

A new effort was started to produce refractory alloys for the SP-100 program for 100-kW(e) reactors. Initially, we are supplying Nb, Ta, and W alloys for irradiation experiments and are preparing process procedures and specifications for refractory metal fabrication.

Postirradiation evaluation of irradiated high-uranium-loaded oxide, aluminide, and silicide-aluminum fuel plates and elements continued. This program is directed to an effort to reduce enrichment levels of test reactor fuels to less than 20% ^{235}U, thus requiring an increase in the total uranium loading. Examinations during this reporting period indicated satisfactory performance of experimental Oak Ridge Research Reactor elements to 70% average burnup.

Work continued in support of the fusion reactor program with the Structural Materials Development Group, involving preparation and processing of experimental stainless and ferritic steels for microstructural and radiation damage evaluation. These alloys are of interest for potential application as the first-wall structural material of a fusion system. The experimental alloys included modifications of the current prime candidate austenitic stainless steel, high-manganese-containing stainless steels, and modifications of T-9 and HT-9 ferritic steels.

As assistance to the Alloying Behavior and Design Group, a program for the scaleup of nickel aluminides was outlined and initiated with Cabot Corporation. Nineteen control rod plates were fabricated for the High Flux Isotope Reactor. Fabrication of these plates into control rods should provide sufficient reactor control for the next six years. During this reporting period, requests for over 750 fabrications and 700 melts were fulfilled.

2.5 STRUCTURAL CERAMICS—P. F. Becher

The research efforts in the Structural Ceramics Group are organized to study ceramic powder characteristics and densification behavior in the tailoring of microstructure and composition of dense ceramics. This is coupled with studies of the explicit effects of microstructure and composition on toughening and slow-crack-growth mechanisms in ceramics. The mechanical behavior of ceramics that can be used in heat engines, high-temperature fossil-fuel-fired systems, and high-power microwave plasma heating devices for fusion systems is also being investigated.

One of the severest limitations of ceramics is low critical fracture toughness (i.e., $K_{Ic} \leqslant 5$ MPa$\cdot\sqrt{\text{m}}$) due to the absence of plastic deformation in the crack tip region. One must then consider novel toughening mechanisms that are applicable to ceramics. We thereby showed that ceramic composites containing second-phase particles or whiskers are substantially tougher than conventional ceramics. Alumina ceramics containing ZrO_2 particles, which undergo a phase transformation in the region adjacent to a crack, exhibited fracture toughnesses at least 3 times those of monolithic ceramics. Analytical electron microscopy revealed that the ability to transform such ZrO_2 particles is controlled by the stabilizer content of the ZrO_2 but not by particle size for particle diameters less than 0.1 μm. Related studies revealed that the critical applied stress for this phase transformation decreases and, thus, that the resultant toughness increases as the temperature and stabilizer content of the ZrO_2 decrease and as particle-particle interactions increase at higher ZrO_2 content. Associated studies of transformation-toughened partially stabilized ZrO_2 and composites address the elevated-temperature toughening and fatigue behavior in these materials, which are being considered for heat engine components.

The above findings indicate that greater toughening can be achieved by judicious tailoring of microstructure and composition. This requires that the unique role of powder characteristics and densification be well understood. Colloid chemistry, including sol-gel processes (jointly with the Chemical Technology Division), combined with analysis of surface and particle characteristics are being used to achieve this.

Our studies of ceramic composites revealed that toughening is also achieved by incorporating other second phases that interact with propagating cracks. For example, SiC ceramics containing TiC particles are toughened by crack deflection. We also showed that even stronger toughening effects occur when very strong SiC single-crystal whiskers are incorporated into alumina ceramics and that such composites exhibit high fracture strengths and toughness at 1000°C.

An analytical model of the microstructural effects on slow crack growth of polycrystalline noncubic ceramics was developed. The model accounts for grain size dependences of both residual stresses and microcracking mechanisms, which then influence crack growth parameters. This model showed that noncubic polycrystalline ceramics such as TiB_2 must have a fine grain size to achieve high fatigue resistance. Joint studies with the Chemistry Division on the densification of fine TiB_2 powder show that carbon additions retard grain growth during densification but that the introduction of oxygen promotes coarsening and detrimentally affects densification. Liquid-phase-assisted densification, which reduces the processing temperatures, also minimizes grain growth, as illustrated by studies of TiB_2 containing nickel, Ni_3Al, or platinum. However, formation of very brittle boride second phases (e.g., with Ni and Ni_3Al additions) limit the maximum toughness (and strength) that can be achieved in such TiB_2 ceramics. Analytical electron microscopy indicated that platinum additions basically yield a metallic boundary phase that should plastically deform and improve the toughness and resistance to slow crack growth of TiB ceramics.

The thermochemical environment also strongly influences how slow crack growth affects the fatigue life of ceramics, as revealed by studies of alumina and beryllia ceramics used as windows in microwave heating devices. Concise thermal stress analysis for windows subjected to dielectric heating was developed for the multitude of potential device operating parameters and the dielectric properties of the window. Recent studies indicate that both fine-grained alumina and transformation-toughened composites are attractive window materials for very high-power high-frequency applications.

In the area of fossil energy materials, analysis of the change in mechanical properties of SiC and other ceramics, when exposed to oxidizing environments or to coal slags, is continuing by use of recently developed test facilities in which the effects of applied stress and temperature can be explicitly determined. Recent results for high-temperature (1100–1300°C) exposures of SiC ceramics to an acidic coal slag revealed that the slag layer thickness affects the oxygen partial pressures at the slag-SiC interface. Both the oxygen partial pressure and the temperature control the corrosion mechanisms and hence the retained strength at these temperatures. Long-term (up to 5000-h) exposures of SiC ceramics to a 1200°C oxidizing environment showed that surface oxidation and retained strengths are also quite sensitive to additives or impurities. Current studies are aimed at defining the processes that dominate the applied stress-temperature dependence of the static fatigue behavior of SiC ceramics.

3. MATERIALS SCIENCE

E. E. Bloom

Research in the Materials Science Section is focused on (1) obtaining a fundamental understanding of the behavior of materials through theory and experiment, (2) developing tools and techniques necessary for obtaining an improved understanding of the relationship between the microstructure and microchemistry of materials and their physical and mechanical properties, and (3) developing improved materials for advanced energy systems.

The section develops and provides important facilities for microstructural and microchemical characterization (transmission, analytical, and high-voltage electron microscopy; X-ray diffraction; and fluorescence) and for physical property determination (thermal conductivity, electrical resistivity, thermal expansion, specific heat, and emittance).

About 70% of our support is from the Office of Basic Energy Sciences, about 20% from the Office of Fusion Energy, and the remaining 10% from the Offices of Fossil Energy and Conservation and Renewable Energy. Research programs on alloy theory, characterization of the structure and chemistry of materials with X rays, diffusion and reaction kinetics, radiation effects on materials, physical properties, and electron microscopy are centered in the Materials Science Section, as are programs for development of alloys for breeder reactor cladding and duct applications and fusion reactor first-wall and structural applications. The staff of the section interacts extensively with the other divisional sections and programs, primarily through materials characterization capabilities. Many of the materials characterization facilities are available to universities and industry through the Shared Research Equipment (SHaRE) Program (Chap. 5). Brief descriptions of activities and accomplishments of groups in the section are given in the following pages.

3.1 PHYSICAL PROPERTIES—D. L. McElroy

The research of the Physical Properties Group focuses on measuring and explaining charge and heat transport phenomena acting in materials of interest to specific programs. The measurements are analyzed with theoretical techniques to obtain the magnitude of electron and phonon scattering components acting in a specific system. This guides further research.

About 30% of this effort was for the Office of Basic Energy Sciences to examine the effects of temperature and composition on the electrical and thermal conductivities of alloys in several systems, including Ni_3Al, TiB_2, Pd-Mo, and bcc iron. This effort revealed the thermal conductivity of Ni_3Al to be quite sensitive to stoichiometry, with a maximum at about 74.8 at. % Ni. The calculated and experimentally derived phonon component agreed and indicated that phonons are responsible for about 25% of the room-temperature thermal conductivity. The electronic Lorenz function is essentially equal to the Sommerfeld value. Our electrical resistivity study on polycrystalline TiB_2 is the first in the range 4.2 to 300 K and revealed a minimum in electrical resistivity near 40 K.

This is caused by the Kondo effect, and, although well known in metals, this is the first data showing this effect in a polycrystalline electrically conducting ceramic. In addition to these studies, we are completing a thermal conductivity review with P. G. Klemens, University of Connecticut.

About 60% of our effort, aimed to improve the technical data base for insulating materials, is supported by the Building Energy Research and Development Division. In-house facilities and subcontracts are used to evaluate building materials. Results are reported to the insulation community, particularly the American Society for Testing and Materials Committee C16 on thermal insulations, for use in developing improved materials and tests. Our simple flat insulation testing device that uses an unguarded nichrome screen wire heater yielded thermal conductivity results within 1% of National Bureau of Standards values. This testing device provided experimental thermal diffusivity values that are only 50% of expected values. These values indicate that radiative transport is active in low-density thermal insulations but is not included in the transient heat conduction equation. Other parts of this effort include modeling heat transfer measurement equipment and measuring the amount of settling of loose-fill attic insulations after installation. For the Building Equipment Program, we were asked to explore ways to improve the thermal resistance of insulating materials used for appliances. An annual energy savings of 1 EJ (1 quad) would result if a material with a specific thermal resistance about 2.5 times that of the best in current use were applied. Our results on evacuated panels containing fumed silica particles indicate a twofold improvement, and results for evacuated amorphous silica powders suggest that a fourfold improvement is technically feasible.

Our measurement capabilities were used to obtain specific materials properties behavior for other systems, including the current voltage behavior of ZnO-base varistors, high-temperature thermal conductivity insulations of fibrous Al_2O_3 and fibrous carbon, and the room-temperature thermal conductivity of rocks, roof insulations, and heat engine insulations.

3.2 DEFECT MECHANISMS—L. K. Mansur

The main theme of the Defect Mechanisms Group is the characterization and understanding of microstructural and atomic processes as they relate to the behavior of materials in the demanding environments of advanced energy production systems. Based on this work, principles are developed for the design of improved alloys. The work covers an extensive basic program in radiation effects on materials; development of tools and techniques for research, including ion beam techniques and surface analysis techniques; and plasma-materials interaction studies of relevance to fusion reactor applications. The radiation effects and ion beam work is supported mainly by the Office of Basic Energy Sciences, and the surface and plasma-materials interaction work is supported mainly by the Office of Fusion Energy. The group combines both theoretical and experimental research to attack major problem areas. It interacts extensively with other groups working in related areas, including structural materials development for fusion and fission reactor applications, electron microscopy, and facilities and techniques support. Our approach is to study the effects of radiation and to apply it as a unique tool to produce extreme changes in microstructure and microcomposition, which are generally unattainable by conventional thermal or mechanical treatments.

The experimental program in radiation effects consists of both neutron and charged-particle irradiations. To characterize and measure radiation effects, substantial use is made of our extensive analytical transmission electron microscopy facilities, our high-resolution Auger electron spectroscopy surface analysis facility, and our mechanical testing devices. For neutron irradiations, we recently started using the Fast Flux Test Facility (FFTF) at Hanford, Washington, and continue to make use of the High Flux Isotopes Reactor (HFIR) and the Oak Ridge Research Reactor (ORR) at Oak Ridge, Tennessee, and the Experimental Breeder Reactor-II (EBR-II) at Idaho Falls, Idaho. Charged-particle work is done mainly on our 5 MeV–400 keV dual- or triple-ion-beam Van de Graaff accelerator facility.

Part of our recent experimental work centers on the concept of a critical radius and critical number of gas atoms for cavity swelling. Theory suggests that cavity swelling can begin only when a critical cavity radius is achieved by stochastic processes or when a critical number of gas atoms is accumulated in a cavity. The critical quantities can be measured when the cavity size distribution breaks into a bimodal distribution, with the smaller cavities defining the critical size. Such measurements were made in an ion-irradiated swelling-resistant ferritic Fe–10% Cr alloy to determine (1) whether a large critical size is responsible for the low-swelling behavior and (2) by theoretical calculation based on measured values, the bias and other fundamental parameters of the alloy. To obtain further insight into the peculiarities of ferritic material, the microstructure of pure iron was compared with that of pure vanadium after neutron irradiation. Similar measurements were made on both high-swelling (low-nickel) and low-swelling (high-nickel) austenitic Fe-Cr-Ni alloys. Preliminary results suggest the remarkable result that the critical radii for these two alloys differ by an order of magnitude. This work may therefore offer part of the long-sought-for explanation of the mechanism responsible for the large differences in swelling with nickel content. An extensive experiment, together with analyses of the effects of helium in neutron-irradiated aluminum, confirmed the critical radius–critical number of gas atoms concept and gave a more complete picture of microstructural evolution. Other experiments on phosphorous-containing stainless steels suggested a mechanism based on these concepts for swelling suppression with increasing phosphorous. By increasing the phosphide-matrix interfacial area, the transmutation-produced helium in the alloy is diluted among more interfacial cavity sites, thereby delaying the time to the achievement of the critical number of gas atoms in a cavity and, therefore, the onset of swelling. This work produced a principle for the design of alloys resistant to swelling.

Work on the effects of pulsed irradiation showed the new result that pulsing can drastically alter the sequence of radiation-induced phase transformations in a complex alloy. Pulsing offers a way to separate time-dependent evolution processes and some insight into possible effects in fusion reactors operated in a pulsed mode. Irradiations at very high pulsing frequencies (10^3–10^5 Hz) were recently completed. A new series of alloys based on Fe–13% Cr–15% Ni with controlled additions was designed to study the mechanistics of phase stability during irradiation. Data from thermal aging studies and the first ion irradiations are now being analyzed. More than 400 specimens of these alloys are under irradiation in the FFTF. Experiments began for the fracture of neutron-irradiated austenitic and ferritic alloys in our high-vacuum high-resolution Auger system to study the effects of solute segregation on mode of failure and to relate this to irradiation conditions and alloy composition.

A major contribution of this task continues to be the development of the theory of microstructural evolution. The theories of swelling, irradiation creep, and some aspects of precipitation effects have received the most emphasis. We recently completed extensive work on our cascade diffusion theory of point defect absorption at dislocations, cavities, and other sinks. This theory goes beyond the almost universally used uniform production models to determine more realistic defect concentrations. The concentrations show extreme fluctuations from point to point and time to time.

Through it we have discovered a new phenomenon of irradiation creep caused by the cascade-induced fluctuations of pinned dislocations. We completed a review and further development of the theory of the interactions of helium with radiation effects. On the basis of this work, a number of new experiments were planned and analyzed to better understand the mechanisms of swelling suppression in swelling-resistant alloys. Comprehensive derivations of the relationships between swelling and irradiation creep by four major mechanisms of irradiation creep were completed. A mechanism for the observed penetration of damage further into ion-irradiated polyatomic specimens (ceramics) than the range of the bombarding particle was proposed and analyzed by more sophisticated damage production computer calculations. The origin of the effect lies in the energetic displacement of lighter target elements by the heavier bombarding ion, thereby creating more highly penetrating projectiles.

Development of tools and facilities for research on defect behavior continues as an important part of our efforts. Capabilities for both low-frequency and high-frequency pulsing of the heavy ion beam are now in place. We also improved our capabilities to deliver a wider number of heavy ion beams. A new method was developed to overcome the difficulties of producing large and reliable currents of zirconium and molybdenum. We increased our use of the accelerator for ion beam implantation, ion beam mixing, and nuclear microanalysis studies. Apparatus for the fracture of irradiated specimens, followed by high-resolution compositional fractography with Auger electron spectroscopy under ultrahigh vacuum conditions, was completed. Work began on a new ion irradiation apparatus designed to permit irradiations on specimens under stress with protons whose range is larger than the specimen thickness.

Our research in plasma-wall interactions for fusion energy applications focused on the measurement of changes in the surface composition of the wall during plasma wall conditioning, a relatively poorly understood process for removing oxygen and some other impurities while also charging the walls with hydrogen. Surface analysis equipment from Oak Ridge National Laboratory (ORNL) was used on (1) TEXTOR, a tokamak at the Institute für Festkörperforschung der Kernforschungsanlage in Jülich; (2) JET, a very large tokamak built by the Joint European Community at Culham, England; and (3) ISX-B, the ORNL tokamak being used to test beryllium as a limiter material.

The studies on TEXTOR showed clearly that it is very difficult to get the base metal to represent more than 60 at. % of the surface composition; O, C, N, S, Cl, and other surface-active impurities make up the balance. On the other hand, it is easy to get the impurity levels as low as 50 at. % and to substitute one impurity for another. This makes it possible to reduce or remove the oxygen, for example, by replacing it with carbon, which is a less objectionable impurity. We monitored the initial wall conditioning of JET. The results of the TEXTOR study were applied to JET, that is, carbon was added to speed the removal of oxygen. This was very effective, and the first JET tokamak plasmas not dominated by impurities were obtained. Measurements in ISX-B were used to characterize the wall conditions and materials transport during the beryllium limiter experiment. Beryllium is transported by sputtering during wall conditioning and as ions in the plasma edge during tokamak shots. Beryllium acts as a strong getter for oxygen and covers the walls; as a result tokamak plasmas low in oxygen are obtained.

3.3 *ELECTRON MICROSCOPY*—J. Bentley

The research of the Electron Microscopy Group centers on obtaining microstructural information on a wide range of metallic and ceramic materials to make reliable structure-property correlations that are necessary in developing advanced materials with superior properties. In the past year we again emphasized the application of new methods and techniques for materials characterization, with efforts to develop and evaluate new instrumentation being confined to a field ion microscope-atom probe. Some of the applications involved collaboration with researchers from industry and universities through the SHaRE program.

X-ray microanalysis research included the first clear demonstration of the magnitude of secondary fluorescence effects [which were shown to produce errors of up to 10% in compositions obtained by X-ray microanalysis in an analytical electron microscope (AEM)]; the further refinement of techniques for the measurement of concentration profiles in backthinned surface-modified materials; and preliminary measurements of atom locations in ion-implanted ceramics with the use of electron channeling analysis (first developed by the staff of the ORNL Solid State Division). As part of a continuing effort to improve the reliability of electron energy loss spectroscopy analysis, measurements of absolute partial ionization cross sections were made to compare with the calculated values used in our data quantification computer programs. The ability to measure lattice parameter changes of 10^{-4} from convergent beam electron diffraction patterns was used to measure thermal expansion coefficients from 100-nm regions. The technique appears to work well and will be applied to a range of phases in ceramic materials. Energy-filtered electron intensities of diffuse and Bragg maxima in electron diffraction patterns from ordered and modulated alloys were measured, and reasonable estimates of the long-range-order parameters for Ni_3Al were obtained from analysis of the data by kinematic theory.

Application of AEM techniques to the measurement of chemical segregation profiles at high spatial resolution began. The effort involves the use of the Monte Carlo programs to account for beam broadening and Fourier transformation techniques for deconvolution. Experimental measurements are also being made. An example is the measurement of grain-boundary antimony enrichment factors of 3 to 4 times the matrix in a doped model stainless steel.

A variety of in situ experiments were performed in the high-voltage electron microscope. The dynamic recording system was completed and fully evaluated. The work on strain localization in precipitation-hardened aluminum-lithium alloys was also completed. A noteworthy result was the formation of dislocation tangles along the edges of grain-boundary precipitate-free zones, resulting in large misorientations (>10°).

A major emphasis of the group involved collaborative applications. In structural ceramics, AEM investigations of zirconia-toughened alumina revealed gross inhomogeneities in the yttrium dopant distribution. Grain-boundary segregation of impurities and β-alumina grains were also observed. All the observed features can degrade the mechanical properties of these complex systems. Identification by AEM of τ-boride intergranular phases in TiB_2 ceramics sintered with nickel or hot-pressed with Ni_3Al allowed significant progress in our understanding the sintering mechanisms in such alloys. The microstructural characterization of ion-implanted ceramics involved implant concentration profile measurements and identification of secondary defects and precipitates. In situ annealing experiments were also performed. Materials studied included Al_2O_3 implanted with zirconium, TiB_2 implanted with nickel, and SiC implanted with chromium.

Collaborative AEM investigations of rapidly solidifed Ni_3Al alloys revealed the presence of a previously unknown metastable tetragonal phase and showed the development of antiphase domain boundaries on {100} as a result of both bulk and thin-foil in situ annealing. The microstructural characterization of aluminum implanted with molybdenum, which involved identification of $Al_{12}Mo$ precipitates in lamellar and continuous-film morphologies and in situ observation of the phase transformation processes, was completed.

The SHaRE projects included examination of creep-deformed SiC (where B_4C intragranular and intergranular precipitates were identified) and the surprising observation of extensive intragranular cavitation in oxidized and reduced lanthanum-doped $SrTiO_3$. The cavities may be the defects that accommodate the nonstoichiometry. Finally, further observations of supported metal catalysts were made. Video recordings of diffraction patterns obtained from operation in the scanning transmission mode with probes of less than 2 nm revealed the internal crystallography of the catalyst particles.

3.4 STRUCTURAL MATERIALS GROUP—A. F. Rowcliffe

The work of the Structural Materials Group centers around understanding the effects of radiation damage on the physical and mechanical properties of complex alloys and on the development of alloys for fusion and fission reactor components subjected to high levels of displacement damage. Eighty percent of the group's support is from the Alloy Development for Irradiation Performance Program funded by the Office of Fusion Energy. The program is primarily concerned with the development of materials that will withstand the temperatures, stresses, chemical environment, and neutron damage levels expected in commercial power-producing reactors, which are several generations away from current experimental fusion machines.

Helium produced by transmutation has a major influence on radiation-induced swelling, microstructural evolution, and mechanical property degradation. Consequently, helium effects are the focus of much of our work. Alloy compositions and reactor spectra are varied to achieve ratios of helium to displacements per atom (He:dpa) similar to fusion reactor conditions; in some experiments helium is introduced into the material before neutron irradiation.

In the austenitic stainless steel class, we concluded that the lifetime of components fabricated from 20%-cold-worked type 316 is limited by void swelling to fluences of 40 to 50 dpa in the range 450 to 600°C, 50 to 70 dpa in the range 300 to 450°C, and 80 to 100 dpa for temperatures below 300°C. Grain-boundary helium embrittlement provides another limitation at 40 to 50 dpa for temperatures above 575°C. Attention is now being focused on austenitic steels with various types of particle dispersion designed to control the scale of helium bubble nucleation. A titanium-modified steel (prime candidate alloy) is showing improved swelling and embrittlement resistance compared with AISI 316 in the presence of very high concentrations of helium (~3000 at. ppm) produced by irradiation in HFIR. The He:dpa ratio achieved in the experiments is 4 to 5 times higher than that anticipated for a fusion machine. To achieve a more realistic end-of-life situation, a sequential HFIR-FFTF irradiation was initiated, which will be used to compare the swelling and embrittlement resistance of some 20 new developmental alloys. The effects of the He:dpa ratio on void nucleation are being studied in a variety of austenitic stainless steels irradiated to 15 dpa in FFTF (He:dpa, ~0.4), HFIR (He:dpa, ~60), and ORR (He:dpa, ~15).

An assessment of the potential of ferritic stainless steels continued with work on an Fe–12% Cr–1% Mo steel (HT-9), an Fe–9% Cr–1% Mo steel (ORNL Mod 9 Cr-1Mo), and a 2 1/4 Cr-Mo steel. Both the 9 Cr and 12 Cr steels showed outstanding resistance to void swelling in breeder reactor program irradiation experiments. Increasing the He:dpa ratio to approximately 3 by irradiating in HFIR produced an increase in cavity density, although total swelling remained very low. The effects of higher helium generation rates on swelling and tensile properties are being explored by irradiating alloys with deliberate additions of nickel, the major source of helium in HFIR irradiation being a two-step reaction of nickel with thermal neutrons.

A crucial question in the application of these materials is the radiation-induced upward shift in ductile-brittle transition temperature. The phenomenon is currently being explored with miniaturized Charpy specimens irradiated in both HFIR and EBR-II at temperatures from 400 to 600°C. Further low-dose experiments in HFIR are being planned to explore this phenomenon at irradiation temperature from 200 to 300°C.

Efforts were initiated this year to control the very high levels of neutron-induced radioactivity in alloys for fusion reactor first-wall and blanket components. Concentration limits were established for certain elements (principally Ni, Mo, Nb, N, Al, and Cu) that would result in radioactive decay rapid enough to permit shallow land burial of discharged components. Both ferritic and austenitic steels were produced, in which the critical elements were substituted with alternative alloying additions. The principal metallurgical properties of these new alloys are being investigated, and an initial irradiation experiment is in place in FFTF.

The quest for reduced activation levels has revived interest in vanadium and its alloys. Current work focuses on the effects of helium concentration on swelling and on ductility. Helium is not produced in vanadium alloys at fusion reactor levels during neutron irradiation in fission reactors. To circumvent this difficulty, a "tritium trick" facility was developed in collaboration with the ORNL Isotopes Division. Tritium is diffused into the vanadium alloys at the planned irradiation temperature; the required fraction is allowed to decay to ^{3}He, and the residual tritium is pumped out under vacuum. This technique is being used to explore the sensitivity of mechanical properties in a range of vanadium alloys to various distributions of helium. Helium-doped alloys are currently being irradiated in FFTF to assess the combined effects of helium and neutron damage on phase stability, swelling, and mechanical properties.

The past year was distinguished by the signing of a collaborative agreement on fusion materials development between the United States and Japan. This agreement provides irradiation space for Japanese materials in both the HFIR and ORR. Eight capsules, with space equally shared between the United States and Japan, will be irradiated in HFIR from 400 to 600°C to doses of 30 and 50 dpa. In addition, two spectrally tailored capsules will be equally shared, operating at temperatures of 60, 200, 300, and 400°C. Currently four of the capsules are in position in HFIR, with the remaining four on schedule for insertion by the end of 1984. All the mechanical testing will be carried out at ORNL, and a new analytical electron microscope provided by Japan is shortly to be installed. As part of the agreement, two Japanese scientists will join the Structural Materials Group.

Other projects in the group involve the application of electron microscopy techniques to the structure of welds in ferritic and austenitic steels and to the structure of oxide films in oxide-dispersion-strengthened materials. Work also began this year in support of the SP-100 Space Reactor Materials Program. The tantalum alloys T-111 and ASTAR 811C, which are being evaluated by the SP-100 project, were irradiated in EBR-II in 1970 as part of the fast reactor absorber program. These alloys were retrieved from long-term storage and are currently undergoing swelling measurements and high-vacuum tensile testing.

3.5 LABORATORY TECHNIQUES AND SUPPORT FACILITIES GROUP—C. K. H. DuBose

The work of the Laboratory Techniques and Support Facilities Group centers around specimen preparation for transmission electron microscopy (TEM) studies and related services. Structural characterization of ceramic materials by TEM has increased considerably over the last 18 months. Being nonconductors, ceramics cannot be thinned to electron transparency by electrolytic thinning as can metal samples. New techniques for sample preparation by use of mechanical erosion for prethinning followed by ion milling to electron transparency were developed. Care must be taken not to alter the crystal structure during the mechanical thinning operation. Even hard materials like TiB_2 can be plastically deformed on the surface. Ion implantation of the surface of many ceramics significantly increases the surface hardness and thus reduces wear. Techniques to study the structure of this thin ion-implanted region were developed.

Techniques were developed for preparing very thin splat-cooled material for TEM. An improved process for electrolytic extraction of precipitates from bulk metal samples is being perfected, and a new technique was developed for preparing fine powder samples.

3.6 SURFACE AND SOLID STATE REACTIONS—J. V. Cathcart

The general goal of the research of the Surface and Solid State Reactions Group is to achieve a better understanding of the mechanisms of gas-metal reactions. During this reporting period major emphasis was on studies of the sulfidation of iron and iron-base alloys. Two specific questions addressed were (1) the extent to which impurity atoms change scale defect concentration and, hence, sulfidation (or oxidation) kinetics and (2) the mechanism by which impurity atoms in a growing scale concentrate sufficiently to form a second phase. Systems being studied include Fe and dilute Fe-base alloys containing Cr, Mn, or Al.

A second major research area involves an investigation of factors controlling the adherence of oxide scales. A dynamic resonance apparatus was designed to study the elastic and anelastic properties of scales and the correlation between these properties and the decohesion of the scale. In addition, we are assessing the importance of impurity atom size and the relative stability of impurity-atom oxides on oxide scale adhesion. Collaborative programs are in progress, in which we study the influence of dispersoid particles on the nucleation stage of oxidation of a nickel-base, oxide-dispersion-strengthened alloy and in which we characterize the high-temperature oxidation properties of Ni_3Al-base alloys.

Progress in these various areas includes (1) measurement of the defect concentrations in FeS samples doped with Cr and Mn as a function of temperature and pressure; (2) characterization of the influence of environment and impurities on the sulfide scale microstructure and on the sulfidation kinetics of Fe; (3) resolution of the cause of apparent nonparabolic kinetics for the sulfidation of Fe; (4) determination of tracer diffusivities for Fe, Cr, and Mn in FeS crystals; (5) characterization of the effect of B, Ce, and Hf additions on the oxidation of Ni_3Al-base alloys; (5) design and construction of a computer-operated dynamic resonance apparatus; and (6) initiation of studies of the influence of selected impurities on scale adherence on Ni_3Al-base alloys.

3.7 THEORY—J. S. Faulkner

The Theory Group develops the techniques of solid state theory and applies them to problems in materials science.

Our development of a modern theory of metallic alloys has reached the point that it is helpful to people engaged in practical alloy development and to those carrying out more basic studies of such solids. We have recently made a special effort to communicate this fact to a wider audience. We organized the theoretical contributions to a conference on High-Temperature Alloys: Theory and Design sponsored by the Metals and Ceramics Division and the Committee on Alloy Phases of The Metallurgical Society of AIME in Bethesda, Maryland, on April 9–11, 1984. A course on Phase Stability of Alloys was taught during the winter quarter of 1984 as part of the in-house continuing education program for staff members at ORNL, which was attended by 21 senior scientists. We gave seminars on alloy theory at such institutions as the Bell Telephone Laboratory and the Materials Science Departments of Columbia University and North Carolina State University.

During this reporting period we developed a mathematically sophisticated technique for the calculation of the electronic states in alloys with the coherent-potential approximation, in which energy integrals are carried out along trajectories in the complex plane. This will dramatically reduce the computer time required for such calculations. We derived for the electrical resistivity of alloys a formula that makes no approximation beyond the one used to calculate the electronic states. Our quadratic-band-theory technique is being used to study the energy differences between the phases of pure metals. These are important parameters in alloy phase diagrams. We are studying the energy of formation of long-range-ordered alloys related to Ni_3Al in support of the collaborative alloy development program of the Metals and Ceramics Division and the Cabot Corporation.

We made improvements in our ability to calculate forces on the nuclei of atoms in large clusters. We will soon be using these results to enhance our studies on metal-metal bonding and the role of impurities in cohesion.

Most alloys of practical interest contain Fe, Co, Ni, Cr, or Mn, which develop magnetic moments spontaneously. We have made progress in understanding the magnetism of these elements at both absolute zero and finite temperatures.

3.8 X-RAY RESEARCH AND APPLICATIONS—C. J. Sparks, Jr.

The research of the X-Ray Research and Applications Group in materials science centers on the application of X rays as a scattering probe and on the interpretation of these X-ray scattering measurements to determine the average structures of periodic crystals, the distribution and strain fields of defects in imperfect crystals, and the local atomic arrangements in crystalline and amorphous solids. We study the atomic arrangements that are relevant to their physical and chemical properties and that are important to advancing practical and theoretical concepts for designing new materials.

A new thrust in our program is to use synchrotron radiation to support our materials science research. We have instrumented a station to be installed in the fall of 1984 at the National Synchrotron Light Source (NSLS). Advanced X-ray optics were designed for our beam line, for which we received an IR·100 award. The use of synchrotron radiation will permit the first systematic study of structures comprising those elements that form the base of our most technologically important alloy systems—Fe with the additions of Ni, Cr, Co, Mn, V, and Ti. Of major interest is the substitutability of these elements for each other in various crystallographic structures and the short-range ordering or clustering among them. A group of university and industrial scientists, organized through the Oak Ridge Associated Universities, have participated in the design and will perform collaborative research at this X-ray station on a variety of materials problems.

The merits of X rays over electrons for microcharacterization of materials by both elemental mapping with fluorescence and structural mapping with diffraction led us to consider the advantages of using synchrotron X-radiation as an X-ray microprobe source. We designed two energy-tunable fluorescent microprobe optical designs, which efficiently use X rays available from bending magnets and insertion devices of synchrotron radiation sources. Compared with other proposed optical systems, the gain in intensity is from 3 to 10 at demagnifications of the focus by factors of 8 and greater. From the bending-arc magnets of the NSLS operating at 500 mA and 2.5 GeV, expected flux in a 1-μm-diam spot is about 2×10^{10} photons/s at 15 keV. With this X-ray intensity, concentration levels 10^{-3} less than those observed with electron probes are detectable. We are currently working with the NSLS staff and others to implement a microprobe that can be applied to materials science problems.

Studies of X-ray-induced resonant and threshold phenomena near absorption edges continued. An understanding of the X-ray interaction processes near absorption edges is important to our developing use of anomalous dispersion to interpret diffuse X-ray scattering. Furthermore, near-edge resonant X-ray spectroscopies can have important attributes such as a sensitivity to the unfilled density of states around a particular atomic species and an ability to resolve structure normally convoluted with the initial hole lifetime width. New and more detailed measurements were made of postcollision interaction and the resonant Raman Auger effect from deep inner-shell holes. These measurements show a discrepancy between existing theory and experiment. Measurements of hard X-ray-induced shakeup and shakeoff near threshold were performed for the first time, and a basic theoretical understanding was formulated.

X-ray diffraction measurements of nonrandom distribution of elements among various coordination sites continues to produce new insights to the crystal chemistry of alloy phases. The presence of minor second phases in steels and other metal alloys can have dramatic effects on the mechanical properties. These effects range from improving certain properties to rendering the alloy unusable in some applications. We have selected for study three second-phase structures that commonly occur: the sigma phase, the spinel, and the tau carbides. Variations in the heat treatment and compositions are used to produce structural changes, followed by diffraction analysis. These studies are bringing new information to the understanding of stability for these phases.

Measurements of site occupation parameters were extended to single crystals of binary W–57.9 wt % Re and Mn–21.7 wt % Cr sigma phases. The latter is unique among sigma phases in that indirect evidence exists for both atomic and magnetic ordering. Extensive conventional Mo $K\alpha$ diffraction data sets were measured to fix the thermal parameters, but these data could not distinguish between the two kinds of atoms. Synchrotron radiation will be used to determine how the atoms are positioned among the different coordination sites to learn more about the chemical substitutability among these atoms.

Despite the small number of iron atoms per unit cell (~3 out of 92 total metal atoms) in a τ-carbide single crystal of composition $(Cr_{22.26}Fe_{0.74})C_6$, their their distributions could be estimated from the conventional X-r diffraction data. The accuracy of these site occupation parameters was confirmed by analyses of synchrotron radiation Bragg diffraction data collected near Cr K and Fe K absorption edges with the same crystal. The distribution parameters form a reasonable extrapolation from the results previously obtained at higher iron contents.

4. PROJECT ACTIVITIES

This section of the report deals with the various project activities in which the division was engaged to a major extent during the report period. Brief statements of the purpose, nature, and scope are presented on the following U.S. Department of Energy (DOE)-sponsored programs: Basic Energy Sciences, Breeder Reactor Materials, Conservation Technology, Fossil Energy Materials, Fusion Energy Materials, Gas-Cooled Reactor Materials, Heavy-Section Steel Technology, and Advanced Space Nuclear.

4.1 BASIC ENERGY SCIENCES–MATERIALS SCIENCES—C. J. McHargue

The purpose of the Basic Energy Sciences-Materials Sciences Program is to establish an understanding of the principles governing the behavior of materials. The thrust of the division's efforts can be characterized as the scientific design of materials in the specific areas of structural ceramics, high-temperature metallic alloys based on intermetallic compounds, and radiation-resistant alloys. The progress at Oak Ridge National Laboratory (ORNL) toward the construction of the High-Temperature Materials Laboratory strongly influenced the choice of these research areas.

The program contains tasks in the areas of theory of alloying, structural characterization, properties, and processing. During this reporting period, new efforts were initiated toward developing a state-of-the-art imaging atom probe facility and toward cooperating with the Solid State Division in ion-beam processing of materials.

The structural ceramics program initiated new studies dealing with the characteristics of powders as they influence the densification process, which interact with studies in the Chemistry and Chemical Technology divisions. The task on fundamentals of welding is involved with the national efforts to establish the American Welding Technology Application Center and has developed a joint research program with industrial laboratories. The high-temperature alloy design task focused on the nickel aluminide system, and the success in ductilizing the polycrystalline forms of this alloy generated several interactions with applied programs and industrial firms.

4.2 BREEDER REACTOR MATERIALS—P. Patriarca

Materials problems are central to economic competitiveness, inherent safety, and reliable performance of liquid metal fast breeder reactor (LMFBR) power plants. In recognition of this fact, DOE has sponsored for many years LMFBR Materials and Structures and Fuels and Materials programs at ORNL. Technology areas in the Metals and Ceramics Division include mechanical properties, fabrication, nondestructive testing, advanced alloys, and support of the *Nuclear Systems Materials Handbook.*

Work under mechanical properties ranges from the performance of exploratory tests for characterizing material behavior to the full-scale acquisition of engineering data. Reference data in air and the effects of metallurgical variables are being determined.

Processes and procedures for component fabrication are being developed and evaluated under the heading of fabrication technology. The emphasis is on welding, including testing and evaluation of ferritic and austenitic steel dissimilar-metal joints.

Tasks in nondestructive testing technology are aimed at inspection of materials and components during manufacture and in service, including situations requiring remote, automated performance. Advanced radiography, ultrasound, and eddy-current techniques are being developed, especially for stainless steel welds, ferritic steel tube-to-tubesheet welds, and high-temperature in-service inspection.

Development of advanced alloys was one of the main achievements of the LMFBR materials programs. A modified 9 Cr-1 Mo steel with elevated-temperature strengh comparable with type 304 stainless steel to 550°C was developed for structural applications. This steel has good fabricability, high resistance to thermal stresses, and good resistance to stress corrosion cracking. Commercialization strategy has emphasized technology transfer, and cooperative programs involving over 40 participating organizations are under way.

Serious design problems can occur in a fast reactor such as the LMFBR if the duct material swells from exposure to irradiation. An alloy development program led to the design of a type 316 stainless steel alloy with adjusted compositions of Cr, Ni, and Ti, which is greatly resistant to neutron-induced swelling. This class of titanium-modified steels is referred to as D-9, and current efforts are aimed at developing the required design data base and at gaining operating experience with full-scale assemblies of fuel pin bundles.

4.3 CONSERVATION TECHNOLOGY—A. C. Schaffhauser

Our materials research and development programs for energy conservation have grown significantly with the renewed DOE emphasis on increased energy efficiency and the realization that materials are a key technology need for advanced energy conservation systems. We have established lead laboratory roles on major materials support tasks in the following conservation projects: (1) Energy Conversion and Utilization Technologies (ECUT) Materials, (2) ECUT Tribology, (3) Ceramic Technology for Advanced Heat Engines, (4) Building and Equipment Insulation, (5) Industrial Waste Energy Recovery, and (6) Electric Energy Systems. In the first four projects, we are responsible for the planning, implementation, and management of the national DOE program, which involves extensive interfaces and subcontracts with industry, universities, and other federal laboratories in addition to research in the Metals and Ceramics Division.

The objective of the ECUT Materials and Tribology projects is to provide the technology base for all advanced energy conservation systems. The projects fund long-range applied research and innovative ideas that are beyond the scope of either the applied programs or basic research. The ECUT Materials Project provided the major funding for our development of the ordered intermetallic alloys and for smaller tasks involving innovative research on ceramic powder synthesis, composites, joining, and surface modification. The major in-house effort in Tribology is on understanding the friction and wear behavior of ceramics in a cooperative effort with various universities. Research on lubricants is led by the National Bureau of Standards, and Argonne National Laboratory is leading the effort on tribological coatings.

The Ceramic Technology for Advanced Heat Engines Project was developed in FY 1983 to meet the ceramic technology requirements of the DOE Office of Vehicle and Engine Research and Development (OVERD) automotive technology programs. The objective of the project is to develop the industrial technology base required for reliable ceramics for application in advanced automotive heat engines. The focus is on structural ceramics for advanced gas turbine and diesel engines, ceramic attachments, and ceramic coatings for thermal barrier and wear applications in these engines. An assessment of needs was completed through extensive interaction with industrial ceramic and engine companies, and a five-year project plan was developed. Technical work began on (1) materials and processing, (2) materials design methodology, and (3) data base and life prediction through ORNL in-house research; subcontracts with industry, universities, and other government laboratories; and an interagency agreement with the Department of Defense. The ORNL in-house work is on powder synthesis, development and characterization of toughened ceramics, and joining of structural ceramics to metals. The construction and equipment for the High-Temperature Materials Laboratory (HTML) is being funded by OVERD. The Ceramic Technology Project will become an integral part of the HTML.

The objective of the Building and Equipment Insulation Project is to develop a reliable data base, testing techniques, and models for heat transfer mechanisms and other physical properties of insulation and building materials. The current focus is on determining the importance of radiant heat transfer and the transient behavior in low-density building and equipment insulation. This research is leading to the development of improved insulation systems.

The focus of our materials task on Industrial Waste Heat Recovery is to determine the performance of current ceramics in high-temperature corrosive industrial furnace flue environments and to develop improved materials. To achieve the large fuel savings possible with ceramic recuperators reliably, we are determining corrosion limits in various industrial environments and developing cost-effective fabrication methods cooperatively with several industrial suppliers and users.

Materials tasks in support of Electric Energy Systems include development of high breakdown voltage ZnO varistors for protection of the electric distribution system, development of ductile amorphous metals with optimum electrical characteristics for high-efficiency motors and transformers, and characterization of polymer insulation for gaseous dielectric transformers.

The interaction of these projects within the Conservation Technology Program and with the Materials Science and Fossil Energy programs at ORNL, other federal agencies, and industry is synergistic and very productive. We anticipate continued growth in these projects but at a somewhat slower rate than in the previous two years.

4.4 FOSSIL ENERGY MATERIALS—R. A. Bradley

The Fossil Energy Materials Program at ORNL consists of four major activities (1) technical support to Oak Ridge Operations (ORO) in the management of DOE's Advanced Research and Technology Development (AR&TD) Fossil Energy Materials Program; (2) technical support to ORO and the Morgantown Energy Technology Center in the management of DOE's Surface Gasification Materials Program; (3) in-house research and development on the AR&TD Fossil Energy Materials Program and the Surface Gasification Materials Program; and (4) research activities for DOE's Major Coal Liquefaction Projects Office, DOE's Office of Coal Liquefaction Technology, and the Pittsburgh Energy Technology Center Coal Liquefaction Instrument and Component Project Office.

The objective of the AR&TD Fossil Energy Materials Program is to conduct research and development on materials for fossil energy applications, with a focus on the longer term and generic needs of the various fossil fuel technologies. The program includes research aimed at a better understanding of materials behavior in fossil energy environments and the development of new materials capable of substantial improvement in plant operations and reliability. In addition to performing in-house research on materials for coal combustion and conversion of coal to liquid and gaseous fuels, ORNL provides technical support to DOE-ORO in the management of the national AR&TD Fossil Energy Materials Program. Our responsibilities include preparation of draft program plans for DOE approval and implementation of the research program through subcontracts with industrial research centers, universities, and other government and national laboratories. The in-house research and development on the AR&TD Fossil Energy Materials Program includes tasks on the development of iron and nickel aluminides, erosion and corrosion in coal combustion environments, corrosion of materials for molten carbonate fuel cells, development of structural ceramics, and assessment of materials needs for advanced steam cycle pulverized-coal plants.

The objective of the Surface Gasification Materials Program is to conduct research and development on materials for application to the specific needs of coal gasification systems. One of the goals of the program is to evaluate innovative fabrication methods that can potentially lower costs and improve reliability and safety for gasifier vessels and components. Another goal is to conduct engineering-scale development and application of materials for coal gasification systems to ensure that the materials of construction for pilot plants and future large-scale plants can be properly selected and specified. Our management responsibilities on the Surface Gasification Materials Program are similar to those for the AR&TD Fossil Energy Materials Program. In-house activities on the Surface Gasification Materials Program include tasks on advanced pressure vessel materials technology and electroslag component casting.

Research on coal liquefaction includes materials design reviews, assessments of materials performance and selection, pilot plant materials testing, chemical vapor deposition coating studies for erosion-resistant materials, and in-plant and laboratory testing of elastomers.

4.5 FUSION ENERGY MATERIALS— J. L. Scott

The objective of the Fusion Energy Materials Program is to develop structural materials for near-term and commercial fusion reactors. By use of several techniques for simulating the effects of 14-MeV neutrons, we have found that austenitic steels, ferritic steels, and vanadium alloys show promise as candidate fusion materials. Type 316 stainless steel is marginal from the standpoint of swelling; a modified alloy, prime-candidate alloy (PCA), is therefore being investigated. Results to date show that 25%-cold-worked PCA is remarkably resistant to swelling up to 5 MW·years/m^2 and shows promise for a lifetime of at least 10 MW·years/m^2. Ferritic steels HT-9 and 9 Cr-1 Mo are very swelling resistant and have excellent tensile properties after exposure to 4 MW·years/m^2. A possible disadvantage is the increase of up to 125°C in ductile-to-brittle transition temperature. For the longer term, low-activation versions of austenitic, ferritic, and vanadium-base alloys are being developed.

4.6 GAS-COOLED REACTOR MATERIALS—W. P. Eatherly, M. J. Kania, and P. L. Rittenhouse

Increasing attention is being given to several gas-cooled reactor (GCR) concepts in the size range 100 to 500 MW(e). The primary reason for this interest is the high degree of inherent safety. Such plants possess intrinsic features that should permit them to recover by passive cooling from worst-accident situations with essentially no release of fission products from the coated-particle fuel and with no damage to the plant core or structures. This is accomplished without reactor operator actions or engineered safeguards.

Three areas of technology important to such GCRs—fuels, graphites, and structural alloys—are being covered in the division's programs. The objective of the fuels work is to provide the technology base for the assurance of safe, reliable, and economic coated-particle fuel. The major current activity is the postirradiation examination of fuels to verify performance margins, including fuel particle failure fraction, and to measure the degree of fission product retention.

Work on graphites is aimed at the development and qualification of nuclear grades for in-core, reflector, and structural applications. Specific tasks within the division involve development of improved materials, determination of physical and mechanical properties and oxidation behavior, failure and design criteria studies, and postirradiation examination and evaluation of irradiated graphites.

Objectives of the structural alloys task are to develop alloys for GCR use and to generate the required materials data base and technology needed for design, construction, and licensing. Work in progress addresses (1) high-temperature mechanical properties including creep, fatigue, and fracture toughness; (2) thermal stability and effects of GCR environment; (3) corrosion and compatibility of materials; (4) fabrication and manufacturing technology; and (5) new alloys for application at very high temperatures.

4.7 HEAVY-SECTION STEEL TECHNOLOGY—R. K. Nanstad

The Heavy-Section Steel Technology Program is funded by the U.S. Nuclear Regulatory Commission and is charged with the performance of research aimed at assurance of the integrity of light-water nuclear reactor pressure vessels. The Metals and Ceramics Division performs materials testing and analyses in support of structural testing tasks such as thermal shock, pressurized thermal shock, intermediate test vessels, and wide-plate crack arrest. We are responsible for performance of a multitask irradiation program to study the effects of neutron irradiation on the properties (the most important of which is fracture toughness) of reactor pressure vessel steels and their weldments.

Series 2 and 3 irradiations and testing were completed, and a final report is being prepared. Those irradiations were conducted to examine the effects of irradiation on the welds with relatively low Charpy upper-shelf energy representing early commercial practice. Series 4 is similar except that the materials represent current practice welds. Charpy impact and tensile testing was completed, and fracture toughness testing will be completed by the end of FY 1984. Series 5 and 6 were conceived to validate the amount and shape of the initiation fracture toughness K_{Ic} and crack arrest toughness K_{Ia} curve shifts, respectively, as a consequence of irradiation. Specimens up to 100 mm thick will be irradiated and tested. The irradiations began in the Oak Ridge Research

Reactor in May 1984. Series 7 is designed to determine the effects of irradiation on stainless steel cladding. Phase I was completed with the irradiation testing of Charpy and tensile specimens of single-wire submerged arc types 309 and 308 stainless steel. The program will continue in FY 1985 with the irradiation of three-wire series arc austenitic cladding obtained from a commercial vendor.

Activities in the nonirradiation area were the development of our crack arrest testing system and the completion of testing for the American Society for Testing and Materials Round Robin Program on Crack Arrest.

We performed extensive metallurgical analyses, including transmission and scanning electron microscopy, in support of all test programs and demonstrated the capability for obtaining accurate, reproducible fracture toughness results with a dc-potential drop system for in-flight crack length measurement.

4.8 ADVANCED SPACE NUCLEAR SYSTEMS MATERIALS

4.8.1 Special Nuclear Projects—M. M. Martin

Improved materials and processes for space and terrestrial applications that utilize radioisotope thermoelectric generators (RTGs) are being developed and evaluated. Activities have included production of iridium alloy–cladding blanks, which contain the heat-generating radioisotopes, and carbon-bonded carbon fiber (CBCF) insulators, which achieve a design operating temperature of about 1550 K at the surface of the cladding blanks in the RTGs. In anticipation of resumed production in FY 1986, an inventory of iridium and a production capability for the insulators and blanks are being maintained at ORNL. In the interim, technology improvements being pursued involve a process to produce CBCF from new raw materials, a consumable arc-melting technique to produce iridium alloy ingots of minimal porosity for blank production, publication of an Isotopic Space Power Materials Handbook, nondestructive examination support for manufacture of advanced thermoelectric elements, and evaluation of measurements of thermal diffusivity and steady-state thermal conductivity on CBCF products. All these efforts will provide an expanding materials and processing data base for future RTGs.

4.8.2 Space Nuclear Projects—R. H. Cooper, Jr.

Efforts continue to establish a substantial role for ORNL in the Space Nuclear Reactor Program. At present the program funded by the Department of Defense, DOE, and National Aeronautics and Space Administration is primarily focused on the development by FY 1985 of a viable concept for a 100-kW(e) reactor. Additional funding may be made available as early as FY 1985 for developing the technologies needed to support multimegawatt space nuclear concepts for possible deployment in the year 2000.

The Metals and Ceramics Division currently has a major role in the fabrication and characterization of the candidate refractory alloys being considered for fuel-cladding and structural applications in 100-kW(e) reactors. Active tasks in FYs 1984 and 1985 include characterization of alloy irradiation effects; determination of the creep properties of Ni-, Ta-, Mo-, and W-base alloys; and fabrication of refractory alloy mill products to support important component testing activities.

A program for the Navy on titanium alloy weldments involves understanding the solidification microstructure and its stability in Ti–6% Al–2% Nb–1% Ta–0.8% Mo alloy. Potentiostatic etching and X-ray microradiography techniques were developed to delineate solidification substructures in titanium alloys. The effect of residual impurities such as boron on the properties of Ti-6211 alloy weldments is being investigated.

Finally, a project was initiated to develop a suitable weldability test for thin sheet materials. A weldability test was developed and used successfully to characterize the weldability of thin sheets of stainless steels.

Wide agreement exists in the technical community that development of an effective refractory alloy technology is critical to the successful deployment of high-performance space nuclear power systems. If a significant national program oriented to the development of high-performance space nuclear power system develops in FY 1986 as planned, the Metals and Ceramics Division is expected to have a lead role in the development of refractory alloys.

5. SPECIALIZED RESEARCH FACILITIES AND EQUIPMENT

In recent years the division has promoted the establishment of selected research facilities with unique capabilities to be operated in the user-dedicated mode. The underlying objective is to advance materials science on a broad national front by making this one-of-a-kind equipment available for collaborative and joint research with the industrial sector and the university community. The effort involves two specialized facilities: Oak Ridge Synchrotron Organization for Advanced Research (ORSOAR) and Oak Ridge National Laboratory (ORNL)-Oak Ridge Associated Universities (ORAU) Shared Research Equipment Program (SHaRE). A brief status report on each activity is presented.

5.1 OAK RIDGE SYNCHROTRON ORGANIZATION FOR ADVANCED RESEARCH—C. J. Sparks, Jr.

This task provides support for a consortium of primarily university and some industrial scientists to share the ORNL X-ray research station at the National Synchrotron Light Source (NSLS) under construction at the Brookhaven National Laboratory (BNL). The user group organization will make available to university staff members and industrial scientists a unique research facility and opportunities for scientific collaboration not available in their respective home institutions. The task also supports one full-time ORAU staff member, A. Habenschuss, to interface with the users and to develop computer support for collaborative research at the ORNL X-ray station.

We have assembled a scientifically competent and motivated group of university and industrial scientists whose research interests not only match the needs of U.S. Department of Energy (DOE) basic energy sciences but will benefit from the application of synchrotron radiation. Currently, 21 university scientists and members of four industrial laboratories have expressed an interest in participating in our consortium. Our annual meeting was held at BNL during the NSLS user's meeting in June 1984. Even though there has been no radiation available from the X-ray ring for our beam line (the NSLS is now three years behind schedule), eight scientists not affiliated with ORNL or ORAU attended the meeting and expressed their continued interest. The date for beginning user experimental research on the X-ray ring at the NSLS was discussed and estimated to be January 1985 at the earliest.

During the delay in completing the X-ray ring at the NSLS, we developed high- and low-temperature specimen chambers and other ancillary equipment, improved our beam line, and continued computer hardware and software development to maximize the utility of the beam line for scientific applications.

5.2 SHARED RESEARCH EQUIPMENT PROGRAM—E. A. Kenik

In the past 18 months the SHaRE experienced growth in the number of internal collaborators and research areas. The program allows participants from universities, industrial research organizations, and other national laboratories access to the wide range of often unique microanalytical facilities. The program is aimed at collaborative research in materials science in areas pertinent to the DOE-ORNL mission and emphasizes areas under investigation in the Metals and Ceramics Division. Facilities and techniques included under SHaRE are analytical and high-voltage electron microscopy, Auger spectroscopy, nuclear microanalysis, surface modification by ion beam techniques, and rapid solidification facilities. An atom probe and imaging atom probe facility will soon be included. Several SHaRE projects support advanced materials development programs in the Metals and Ceramics Division, such as long-range-ordered alloys, nickel-base aluminides, high-temperature ferritic alloys, and high-performance ceramics.

During this period, the Division of Materials Sciences, Office of Basic Energy Science, provided funds through ORAU to support the SHaRE activity. Program funds are used for travel and living expenses of SHaRE participants while at ORNL and for the support of G. L. Lehman, an electron microscopist. His responsibility is to familiarize SHaRE participants with the electron microscope and computer facilities and to participate in SHaRE research when appropriate. His presence has made possible the high level of SHaRE participation and minimized interference with in-house programs.

A steering committee reviews all proposed SHaRE projects and defines SHaRE program policy. The members in FY 1983 were E. A. Kenik, ORNL; C. L. White, ORNL; D. H. Garber, ORAU; J. J. Hren, Professor, Department of Materials Science and Engineering, University of Florida, Gainesville; and K. R. Lawless, Professor and Chairman, Department of Materials Science, University of Virginia, Charlottesville.

Three changes were made in the FY 1984 steering committee: R. Wiesehuegel, ORAU, replaced D. H. Garber; P. S. Sklad, ORNL, replaced C. L. White; and R. F. Davis, Professor, North Carolina State University, Raleigh, replaced K. R. Lawless.

During this reporting period, 20 SHaRE projects were active, involving about 41 participants. Some 20 to 25 papers based on SHaRE research were published, and about 30 presentations were made at technical meetings.

6. MISCELLANEOUS ACTIVITIES

This chapter presents work in progress in the division other than that discussed in previous chapters.

6.1 METALLOGRAPHY—R. S. Crouse

The Metallography Group of the Metals and Ceramics Division provides technical assistance in general metallography, including postirradiation examination and electron beam microanalysis. These services are available not only to the division but to the entire Oak Ridge complex and to outside organizations such as Battelle Pacific Northwest Laboratories (PNL), Tennessee Valley Authority, and U.S. Department of Energy. During the reporting period, the group processed 4400 specimens and made 10,000 black-and-white negatives, 600 color negatives, and 4000 slides and viewgraphs.

6.1.1 General Metallography and Postirradiation Examination—
R. S. Crouse and B. C. Leslie

In the field, metallography continues to be performed for the Engineering Technology Division at the Y-12 Plant in support of its full-scale creep tests and stress rupture tests. Test pieces are polished, etched, and replicated in situ at specified intervals during testing to follow the progress of changes in the microstructure.

The hot cell metallography facility is used to analyze stainless steel capsules containing $^{137}CsCl$ for Battelle PNL as part of its continuing study of the long-term compatibility of container materials with high-radiation-level reactor wastes. Four capsules were sectioned and fully examined during this reporting period.

6.1.2 Electron Beam Microanalysis—R. S. Crouse and T. J. Henson

A fully automated electron beam microprobe (probe) X-ray analyzer was installed and became operational. This instrument performs rigorous quantitative chemical analyses on flat polished specimens of metals, ceramics, and minerals about 1 μm in diameter. All operations are computer controlled.

The probe was recently used to determine the concentration and distribution of Ca, Mg, Na, and Sr in dolomite crystals from the Florida aquifer. This enables the geologists to estimate the mode and time of formation of the rock strata.

6.2 SPECIAL PROJECTS—R. J. Gray

This activity focuses on projects requiring special applications of metallographic techniques and investigative skills. Most of the work is on failure studies, but examinations are also made on materials behavior under specific circumstances. One study involved the metallographic analysis of a number of transition or dissimilar-metal weld joint failures that occurred during elevated-temperature service (fossil fired) or during laboratory specimen testing. A report was published, which included the study of crack initiation and propagation in the heat-affected zone adjacent to the fusion line of the weld as shown in microstructures with light optical and scanning electron microscopy.

Another study determined the cause of a blank-firing adapter explosion that occurred during a security exercise at Oak Ridge National Laboratory. The explosion was credited to the firing of a live round of ammunition containing a recessed projectile that was inadvertently mixed with blank ammunition. A report was published on this work, and an open-literature publication is in press.

An article was published on the microstructural study of series 300 stainless steel sheet welds and tensile specimens. Magnetic etching was used to detect ferromagnetic and paramagnetic conditions in the microstructure as related to welding and testing conditions.

APPENDIXES

Appendix A

BUDGET AND FINANCIAL CHANGES

During the past 18 months, the divisional operating budget increased $1.7 million for a total FY 1984 budget of $27.7 million. The increase occurred in FY 1983, with a small decrease of $240 thousand in FY 1984—the first decrease in total support in many years. These data are tabulated in Table A.1.

A significant change in division funding not included above is the increase in assigned U.S. Department of Energy (DOE) pass-through funds to support subcontracting, Table A.1. These funds have increased from about $3.8 million to an estimated $6.9 million; additional personnel are required to manage the activity (see Appendix C). Two projects (conservation and fossil), each representing over 40%, are the primary sources of these funds; however, most programs now support work of this type. The increase over this period has been primarily in conservation, which has increased by more than a factor of 3 to an estimated $3 million. This growth is expected to continue during the coming year.

In FY 1983 the budget for basic energy sciences, conservation, space, and work for others increased considerably, but waste management and nuclear fission energy suffered large decreases. In FY 1984 a large increase in conservation and a smaller one in basic energy sciences were offset by losses in fission energy, space, waste management, Nuclear Regulatory Commission support, fossil energy, and work for others. The waste management program, which suffered decreases in both years, is now in the process of being transferred to the Operations Division.

The desired diversification of division funds discussed in the previous report has continued. The programs in fission energy, which as late as 1978 constituted over 60% of the division budget, have continued to decrease and now represent only 14% of the division effort. The largest program is now basic energy sciences, and, with its rapid growth, conservation is second. Five major programs now constitute between 10 and 25% of the budget; no major program supports less than 5%.

Table A.1. Division budget

Thousands of dollars

Fiscal year	Operating funds	Subcontracting funds
1982	26,020	3,786
1983	27,941	4,570
1984[a]	27,701	6,900

[a]Estimated.

Appendix B

PERSONNEL SUMMARY

The decline in personnel discussed in the two previous reports was reversed during this period. Increases have occurred in all personnel categories during the period January 1, 1983, through June 30, 1984 (Table B.1). The permanent staff increased by four technical and seven support people. We used two-year appointments to increase the technical staff an additional three for a total increase of seven technical people. In the support area, the secretarial staff was increased, and the technician staff was decreased by one.

The increase of 7 in the technical staff was achieved by obtaining 15 new people: 12 were hired, 1 was transferred, and 2 received internal promotions. The high quality of the division was thus maintained with the new hires. All but one of the hires are Ph.D's, and the one has extensive experience in a needed area. Of the 13 people obtained from outside the division, 10 had three years or more experience; the average for the entire group was eight years. A wide range of disciplines is represented by this group, six being trained in metallurgy or materials science, three in physics, two in chemistry, one in both ceramics and engineering mechanics, and two with no degree.

Of the eight people who left the division, only three went to outside jobs, four retired, and one was promoted and transferred to another division. Of this group only three or 37% had Ph.D's; two had no degree.

The division staff was again augmented by technical guests from the outside. On July 1, 1984, we had 13 assigned to the division compared with 5 on January 1, 1982. During these 18 months a total of 107 long-time guests worked in the division. Their appointments ranged from two months to two years. The wide source of these technical guests is tabulated in Table B.2.

Table B.1. Changes in division staff from January 1, 1983, through June 30, 1984

	Technical			Support			Total change
	1/1/83	7/1/84	Change	1/1/83	7/1/84	Change	
Permanent employees	127	131	+4	106	113	+7	+11
Temporary employees, >ten months	5	8	+3	0	0	0	+3
Loanees to other divisions	4	3.5	−0.5	2	4	+2	+1.5
Loanees from other divisions	1	2	+1	2	2	0	+1
Part-time employees	4	4		6	8	+2	+2
Long-time guests	5	13	+8	0	0	0	+8

Table B.2. Source of technical guests

Source	Number
American universities	72
Industry	7
Foreign countries	16
Other national laboratories	1
Other	11
Total	107

Appendix C

ORGANIZATIONAL STRUCTURE AND CHART

During this reporting period, the organization of the division remained relatively stable. In the implementation of 11 programmatic activities, we continue to operate with three functional research sections comprising 18 functional laboratories and with one service section. An organization chart of the division as of July 1, 1984, is included in this appendix.

The major change in organization was the expansion and formalization of the conservation programs under A. C. Schaffhauser. Under the U.S. Department of Energy assistant secretaries for conservation and renewable energy, the division is now managing two major phases of the national conservation program. The major portion of both these tasks involves supervision of outside subcontracts; however, as an incentive, about 20% of each program may be kept in house. D. R. Johnson returned from the Oak Ridge Gaseous Diffusion Plant as task leader of ceramic technology for advanced heat engines, the purpose of which is to develop a technology base for reliable application of ceramics for gas turbine and adiabatic diesel engines. J. A. Carpenter leads a task on conversion and utilization technologies aimed at long-range applied research and exploration of materials and tribology for advanced conservation technologies. A joint program under T. S. Lundy with the Energy Division on building thermal envelope systems has continued. A conservation administrative group was established under M. C. Matthews.

In what is expected to be a growth area, a new space nuclear projects task under R. H. Cooper was established. This office will develop materials, primarily refractory metals, for space reactors. The former space power program aimed at developing radioisotopic power sources continues at a decreased rate under M. M. Martin.

F. G. Homan, who was manager of both the division Nuclear Regulatory Commission program and waste program, was promoted and transferred to the Operations Division. With decreased support expected in these tasks, no replacement was appointed.

Group leaders of two functional laboratories were replaced. S. A. David is now in charge of welding and brazing, replacing G. M. Goodwin, who has returned to the laboratory to conduct research. P. T. Thornton heads the publications office, replacing F. R. Cox, who retired.

During this period the division made a considerable recovery from the low point in personnel during the preceding period, with an increase of about 20 people. Changes by section are tabulated in Table C. These figures include changes in loanees and in long-time nonstudent guests and therefore do not correspond directly to the figures on division personnel included in Appendix B. Table C.1 shows that the staff in most functional laboratories has been quite stable and that the largest increases were in the managers and task leaders and in increased secretarial services for them as a result of the increase in subcontracting demand previously mentioned. The largest increases for individual laboratories were four in each of Alloying Behavior and Structural Ceramics, with increases of three in each of Defect Mechanisms and Electron Microscopy. The largest decrease was six in Coating and Tribology, with three in Materials Compatibility.

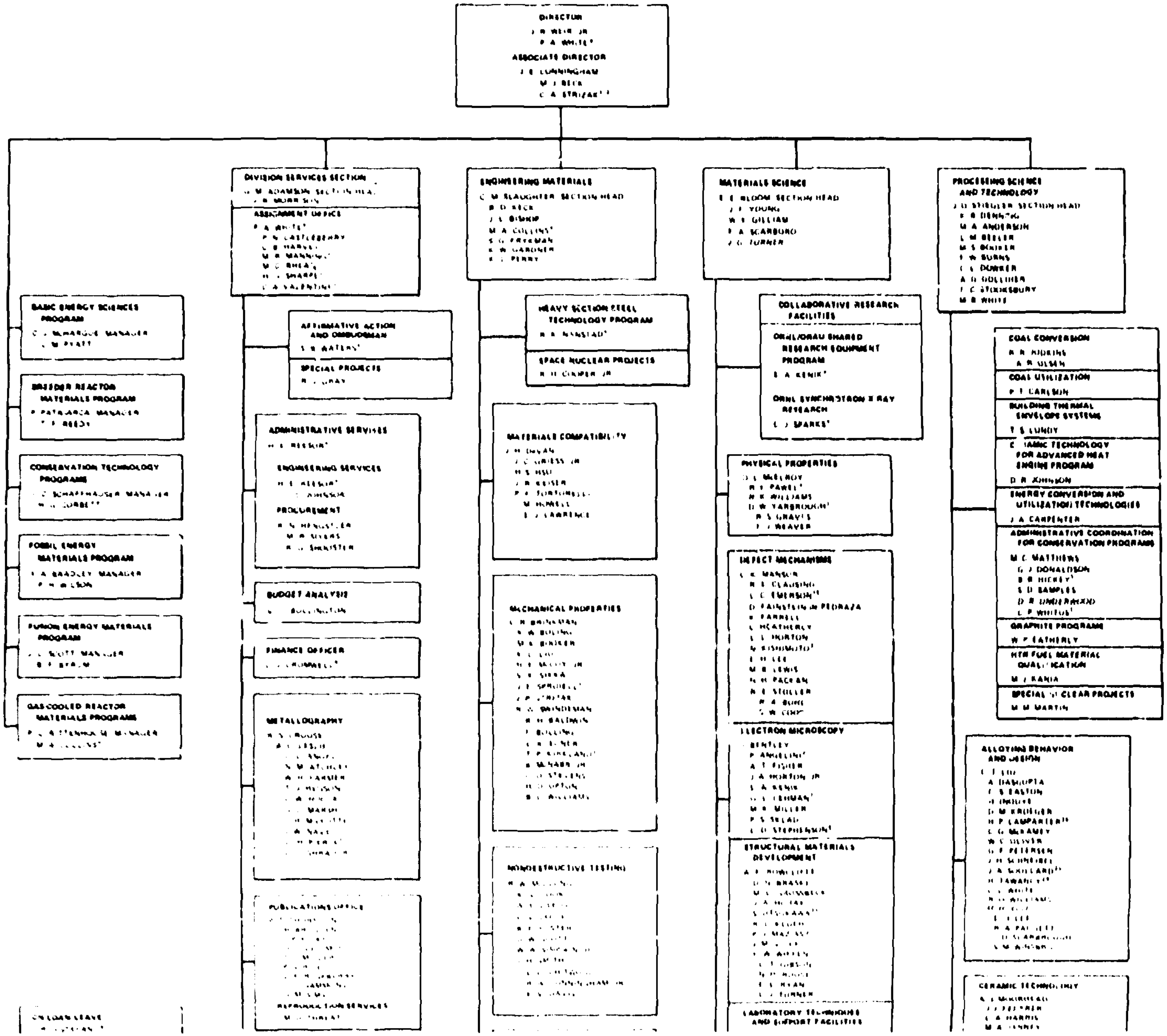
Table C.1. Section manpower changes

Section	Manpower changes		Total
	Technical	Support	
Division services	−1	+2	+1
Engineering materials	+2.5	−5	−2.5
Materials sciences	+11	−2	+9
Processing science and technology	0	+2	+2
Managers and task leaders	+6	+1	+7
Secretarial[a]	0	+5	+5
Total increase	18.5	3	21.5

[a]Four additional part-time seretaries were also added.

METALS AND CERAMICS DIVISION

JULY 1 1984



ON LOAN LEAVE
[illegible]

PUBLICATIONS OFFICE
[illegible]
REPRODUCTION SERVICES
[illegible]

QUALITY ASSURANCE
[illegible]

SAFETY
[illegible]

TECHNICAL EDITOR
[illegible]

NONDESTRUCTIVE TESTING
[illegible]

PRESSURE VESSEL TECHNOLOGY
R. K. NANSTAD[*]
R. G. BERGGREN
[illegible]
D. P. EDMONDS
[illegible]
J. J. McGOWAN
A. M. NASRELDIN[*]
T. N. JONES, JR.
T. G. OWINGS, JR.
R. L. SWAIN

WELDING AND BRAZING
S. A. DAVID
[illegible]
J. F. HAMMOND
[illegible]
[illegible]
M. L. SANTELLA
[illegible]

SPECIAL PROJECTS
[illegible]

[illegible] STEPHENSON[*]

STRUCTURAL MATERIALS DEVELOPMENT
A. F. ROWCLIFFE
D. N. BRASKI
M. L. GROSSBECK
J. A. HORAK
S. JITSUKAWA[*]
[illegible]
P. J. MAZIASZ
J. M. VITEK
F. W. WIFFEN
[illegible]
[illegible]
[illegible]
[illegible]

LABORATORY TECHNIQUES AND SUPPORT FACILITIES
[illegible] DUBOSE
L. P. HALTOM
R. F. RUSSELL
W. H. SMITH

SURFACE AND SOLID STATE REACTIONS
J. V. CATHCART
R. E. DRUSCHEL
F. A. LIST III
R. A. McKEE
R. E. PAWEL[*]
J. J. CAMPBELL

THEORY
J. S. FAULKNER
W. H. BUTLER
A. P. MALLIN
D. M. NICHOLSON[*]
G. S. PAINTER
G. M. STOCKS

X-RAY RESEARCH AND APPLICATION
C. J. SPARKS, JR.[*]
B. S. BORIE
O. B. CAVIN
A. HABENSCHUSS[*]
G. E. ICE
C. H. KINIMELIS[*]
[illegible]
H. L. YAKEL

C. G. McKAMEY
W. C. OLIVER
G. P. PETERSEN
J. H. SCHNEIBEL
J. A. SHILLAND[*]
H. TAWANCY[*]
C. L. WHITE
R. O. WILLIAMS
M. H. YOO
E. H. LEE
R. A. PADGETT
J. O. SCARBROUGH
S. M. WINSBRO

CERAMIC TECHNOLOGY
A. J. MOORHEAD
J. L. FLEENER
L. A. HARRIS
M. A. JANNEY
C. R. KENNEDY
D. E. KOPP[*]
R. J. LAUF
E. L. LONG, JR.
J. M. ROBBINS[*]
T. N. TIEGS
B. H. CHILCOAT
J. D. FLYNN
J. W. GEER
C. HAMBY
J. E. HOUSTON
C. P. JEFFERS
P. J. JONES
H. KEATING
M. C. VANCE
C. A. WALLS

COATINGS AND TRIBOLOGY
W. J. LACKEY
A. J. CAPUTO
G. W. CLARK
D. P. STINTON
C. S. YUST
C. E. DEVORE
H. H. LIVESEY
R. L. LINDEN
[illegible] McLAUGHLIN[*]

METALS PROCESSING
R. L. HEESTAND
[illegible] COPELAND
C. E. DUNN[*]
[illegible]
G. E. ANGEL
R. S. BLAKELY
[illegible] HOLLAND
R. L. MARTIN

STRUCTURAL CERAMICS
P. F. BECHER
P. ANGELINI[*]
S. BAIK
A. BLEIER
H. G. BOHN[*]
G. C. FARLOW[*]
M. K. FERBER
[illegible]
[illegible]
W. B. STINES
W. H. WARWICK
S. D. WATERS[*]

[illegible]

Appendix D

HONORS AND AWARDS

Excellence in research is a constant divisional objective, and peer recognition is one measure of how well staff members of the division perform in meeting that important goal. The division therefore monitors recognition accorded staff members by their peers. Of particular interest is the frequency with which staff members are cited and rewarded for demonstrating outstanding talent and ability in fulfilling their professional roles in the scientific and engineering community. The type of recognition received varies in degree but tends to fall into one of the following generic categories: honorific awards, exhibition prizes, elected officers and members, commendations, certification and registration, patents issued, conference organizers, conference chairmen, session chairmen, and appointments. A listing of citations by generic category during the past 18 months follows.

HONORIFIC AWARDS

B. Ashdown (editor) and **D. P. Stinton**, **W. J. Lackey**, and **R. D. Spence** (writers) won the Award of Merit (third place) in the Journal Articles and Conference Papers category of the Society for Technical Communication, East Tennessee Chapter, 1983 Competition, for the article "Production of Spherical UO_2-UC_2 for Nuclear Fuel Applications Using Thermochemical Principles," published in the *Journal of the American Ceramic Society* 65(7), 321–24 (1982).

E. E. Bloom was elected a Fellow of the American Society for Metals.

Irene Brogden (editor), **J. E. Cunningham** and **J. R. Weir** (coauthors), and **D. L. LeComte** (composition and makeup) won the Award of Merit (third place) in the Periodic Activity Reports category of the Society for Technical Communication, East Tennessee Chapter, 1984 Competition, for the *Metals and Ceramics Division Progress Report for the Period Ending December 31, 1982.*

Irene Brogden (editor) and **D. P. Stinton**, **P. Angelini**, **A. J. Caputo**, and **W. J. Lackey** (writers) won the Award of Distinction (first place) in the Journal Articles and Conference Papers category of the Society for Technical Communication, East Tennessee Chapter, 1983 Competition, for the article "Coating Crystalline Nuclear Waste Forms to Improve Inertness," published in the *Journal of the American Ceramic Society* 65(8), 394–98 (1982).

C. V. Dodd and **L. D. Chitwood** (with **W. E. Deeds** of the University of Tennessee) won an IR-100 Award from *Industrial Research* for their development of a Multiple-Frequency Eddy-Current Testing Instrument.

W. P. Eatherly received the George Skakel Memorial Award from the American Carbon Society in recognition of his outstanding contributions to the science and technology of carbon.

C. T. Liu and **C. C. Koch** won an IR-100 Award from *Industrial Research* for their development of NIFE Aluminide.

L. K. Mansur was elected a Fellow of the American Nuclear Society.

L. K. Mansur, **K. Farrell**, **L. L. Horton**, **E. H. Lee**, **M. B. Lewis**, and **N. H. Packan** won in the category of Significant Implication for Energy Technology of the U.S. Department of Energy Materials Sciences Research Competition for their entry, "The Effect of Helium Gas and Pulsed Irradiation on Materials Behavior in Fusion Reactors."

R. W. McClung received the American Society for Testing and Materials Longevity Award for 25 years of continuous service in ASTM standardization.

B. McNabb, Jr., received the American Society for Metals Engineering Associate's Achievement Award for 1983.

C. J. Sparks, Jr., and **G. E. Ice** (with **Melvin Willey** of the Fusion Energy Design Center) won an IR-100 Award from *Industrial Research* for their development of an X-Ray Monochromator: High-Performance X-Ray Focusing Optics for Synchrotron Radiation.

G. M. Stocks was elected a Fellow of the American Physical Society.

P. F. Tortorelli was selected as the Outstanding Young Member by the Oak Ridge Chapter of the American Society for Metals.

EXHIBITION PRIZES

G. M. Goodwin and **C. P. Haltom** (with **P. A. Sanger**, Airco) won honorable mention in Class 1—Optical Microscopy; Iron, Steel, Stainless Steel, Nickel, and Nickel Alloys, of the International Metallographic Exhibit of the International Metallographic Society, July 1983, for their poster "Unintentional Carburizing Treatment Improves a Semiconductor."

C. P. Haltom, **C. L. Angel**, **J. W. Nave**, and **G. M. Goodwin** received 14th prize in the 1983 Nikon International Small World Competition for their entry "Superconductor Containing Bundles of Nb_3Sn Filaments in a Copper Matrix." This picture illustrates the month of August on Nikon's 1984 Small World calendar.

V. K. Sikka, **C. W. Houck**, and **J. M. Vitek** (with **K. S. Modrell**, Information Division) won first place in Class 1—Optical Microscopy; Iron, Steel, Stainless Steel, Nickel, and Nickel Alloys, of the International Metallographic Exhibit of the International Metallographic Society, July 1983, for their poster "Recrystallization in a Long-term Creep Specimen."

D. P. Stinton and **N. M. Atchley** were awarded first place in the Different or Combined Techniques Category of the Ceramographic Contest held in conjunction with the American Ceramic Society Annual Meeting in Chicago, Illinois, April 24–27, 1983, for a poster describing the characterization of hydrofracture grout.

G. C. Wei and **J. R. Mayotte** were awarded second place in the Optical Microscopy category of the Ceramographic Contest held in conjuntion with the American Ceramic Society Annual Meeting in Chicago, Illinois, April 24–27, 1983, for a poster on "SiC Sintering Behavior."

ELECTED OFFICERS AND MEMBERS

J. **Bentley** was elected to serve on the Board of Review of *Metallurgical Transactions* for a three-year term, starting in 1984.

W. J. **Lackey** was elected Vice-Chairman of the Nuclear Division of the American Ceramic Society for 1983–84.

D. L. **McElroy** was elected to serve a second term as Chairman of the Governing Board of the International Thermal Conductivity Conference, 1984–85.

G. M. **Slaughter** was elected a Trustee of the American Society for Metals for a three-year term.

C. J. **Sparks**, Jr., was elected Chairman of the Executive Committe of the Users National Synchrotron Light Source (Brookhaven National Laboratory) for a two-year term.

R. W. **Swindeman** was elected to serve as a member of the Executive Committee of the Pressure Vessels and Piping Division of the American Society of Mechanical Engineers for a five-year term, effective June 1984.

P. T. **Thornton** was elected Vice-President–Membership of the Association of Information Systems Professionals for the 1984–85 term.

C. S. **Yust** was elected Chairman of the Nuclear Division of the American Ceramic Society for 1983–84.

COMMENDATIONS

G. M. **Adamson** received a letter of appreciation for excellent service on the ORNL High Pressure Equipment Review Committee during 1983.

E. S. **Bomar, Jr.**, received a letter of appreciation for excellent service on the Radioactive Operations Committee of Oak Ridge National Laboratory during 1983.

R. E. **Clausing** received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course on Fundamentals of Vacuum Technology.

J. E. **Cunningham** received a Certificate of Governance from the American Nuclear Society in recognition of special services rendered to the Society.

J. E. **Cunningham** received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course on Fundamentals of Vacuum Technology.

D. S. **Easton** received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course on Fundamentals of Vacuum Technology.

D. P. **Edmonds** received a letter of commendation from the Clinch River Breeder Reactor Project Office for outstanding work in reviewing the project's mechanical designs and in spearheading the Steam Generator Program.

J. I. Federer, R. L. Heestand, H. Inouye, C. T. Liu, and **A. C. Schaffhauser** (with **R. G. Donnelly** and **K. H. Galloway**) received a commendation from the U.S. Department of Energy and the Jet Propulsion Laboratory for their significant contributions to the success of the Voyager Outerplanetary program. The citation and framed photograph showing Jupiter and its moon were presented to H. Postma on their behalf in ceremonies at ORNL.

R. J. Gray received the President's Award of the International Metallographic Society in appreciation of his outstanding contribution to the society through his leadership and assistance in all the society's many activities.

J. C. Griess received a letter of appreciation for excellent service on the Reactor Experiments Review Committee of Oak Ridge National Laboratory during 1983.

L. Heatherly received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course on Fundamentals of Vacuum Technology.

R. L. Heestand received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course on Fundamentals of Vacuum Technology.

R. R. Judkins received a letter of appreciation for excellent service on the Reactor Operations Review Committee of Oak Ridge National Laboratory during 1983.

M. Matthews received a certificate of appreciation from Oak Ridge National Laboratory for time and effort in serving as instructor for the course Guide for Executive Secretaries and Administrative Assistants.

J. L. Scott received a Certificate of Appreciation from the American Nuclear Society for serving as the General Chairman of the Fifth Topical Meeting on the Technology of Fusion Energy, Knoxville, Tennessee, April 26–28, 1983.

P. F. Tortorelli received the President's Citation from the Oak Ridge Chapter of the American Society for Metals for 1982–83.

CERTIFICATION AND REGISTRATION

K. V. Cook received recertification (for five years), Level III (professional level) in ultrasonics and liquid penetrants, from the American Society for Nondestructive Testing.

C. V. Dodd received recertification (for five years), Level III (professional level) in eddy currents, from the American Society for Nondestructive Testing.

B. E. Foster received recertification (for five years), Level III (professional level) in radiography, from the American Society for Nondestructive Testing.

R. W. McClung received recertification (for five years), Level III (professional level) in ultrasonics, radiography, eddy currents, and liquid penetrants, from the American Society for Nondestructive Testing.

J. H. Smith received recertification (for five years), Level III (professional level) in ultrasonics and eddy currents, from the American Society for Nondestructive Testing.

PATENTS ISSUED

D. P. Stinton, "Mixed Uranium Dicarbide and Uranium Dioxide Microspheres and Process of Making Same," U.S. patent 4,367,184, Jan. 4, 1983.

B. E. Foster and **E. V. Davis**, "Pentrameter Positioner for Bore-Side Radiography of Tubes," U.S. patent 4,368,996. Jan. 18, 1983.

P. Angelini, W. J. Lackey, D. P. Stinton, R. E. Blanco, W. D. Bond, and **W. D. Arnold, Jr.**, "Method for Primary Containment of Cesium Wastes," U.S. patent 4,376,792, Mar. 15, 1983.

K. V. Cook, R. A. Cunningham, and **H. T. Murrin**, "Ultrasonic Probe for Inspecting Double-Wall Tube," U.S. patent 4,391,143, July 5, 1983.

R. J. Lauf and **C. S. Morgan**, "Solid Electrolytes Strengthened by Metal Dispersions," U.S. patent 4,393,124, July 12, 1983.

C. S. Morgan, "Method for Fabricating Cermets of Alumina-Chromium Systems," U.S. patent 4,397,963, Aug. 9. 1983.

J. H. DeVan and **J. E. Selle**, "Method for Inhibiting Alkali Metal Corrosion of Nickel-Containing Alloys," U.S. patent 4,398,967, Aug. 16, 1983.

R. L. Heestand and **B. Heshmatpour**, "Method for Refining Contaminated Iridium," U.S. patent 4,406,693, Sept. 27, 1983.

P. A. Haas and **W. B. Stines**, "Method for Improved Decomposition of Metal Nitrate Solutions," U.S. patent 4,409,157, Oct. 11, 1983.

C. T. Liu, H. Inouye, and **A. C. Schaffhauser**, "Long-Range-Ordered Alloys Modified by Group IV-B Metals," U.S. patent 4,410,371, Oct. 18, 1983.

CONFERENCE ORGANIZERS

A. Bleier served as organizing chairman for the American Chemical Society's 58th Colloid and Surface Science Symposium on Structures in Concentrated Suspensions, Pittsburgh, Pennsylvania, June 10–13, 1984.

R. A. Bradley served as an organizer for the U.S. Department of Energy Symposium on Electroslag Component Casting, Morgantown, West Virginia, June 1–2, 1983.

R. A. Bradley served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

J. E. Cunningham served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

F. J. Homan served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

R. R. Judkins served as an organizer for the U.S. Department of Energy Symposium on Electroslag Component Casting, Morgantown, West Virginia, June 1–2, 1983.

P. Patriarca served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

A. C. Schaffhauser served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1-3, 1984.

J. L. Scott served on the organizing committee for the Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

P. F. Tortorelli served as organizer of the Symposium on Advances in Materials Analysis, Oak Ridge, Tennesse, sponsored by the Oak Ridge Chapter of the American Society for Metals, April 15, 1983.

F. W. Wiffen served as organizer for the Office of Fusion Energy, U.S. Department of Energy Workshop on Copper and Copper Alloys for Fusion Reactor Applications, Washington, D.C., April 14–15, 1983.

D. W. Yarbrough was appointed organizer of the Symposium on Properties, Testing, and Utilization of Materials for Energy Conservation in Industrial Applications for the National Meeting of the American Institute of Chemical Engineers to be held in Philadelphia, Pennsylvania, August 20–23, 1984.

CONFERENCE CHAIRMEN

J. E. Cunningham served as program chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

D. W. Yarbrough was selected as chairman of the 19th International Thermal Conductivity Conference to be held in 1985 at Tennessee Technological University.

SESSION CHAIRMEN

P. Angelini served as chairman of the session on Novel Techniques of Surface Modification for the Fourth Annual Meeting of the Tennessee Valley Chapter of the American Vacuum Society, Knoxville,Tennessee, May 3, 1984.

P. F. Becher served as chairman of the session on Solid State Studies of Ceramics at the Gordon Research Conference, New London, New Hampshire, July 24–29, 1983.

J. Bentley served as session chairman of the Symposium on Advances in Materials Analysis, Oak Ridge, Tennessee, sponsored by the Oak Ridge Chapter of the American Society for Metals, April 15, 1983.

R. A. Bradley served as session chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1-3, 1984.

F. J. Homan served as session chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

L. L. Horton served as session chairman of the Symposium on Advances in Materials Analysis, Oak Ridge, Tennessee, sponsored by the Oak Ridge Chapter of the American Society for Metals, April 15, 1983.

R. R. Judkins served as session chairman of the Diamond Jubilee Meeting of the American Institute of Chemical Engineers, Washington, D.C., November 2, 1983.

P. Patriarca served as session chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

A. C. Schaffhauser served as session chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

J. L. Scott served as session chairman of the American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984.

D. W. Yarbrough was appointed session chairman of the Symposium on Properties, Testing, and Utilization of Materials for Energy Conservation in Industrial Applications for the National Meeting of the American Institute of Chemical Engineers to be held in Philadelphia, Pennsylvania, August 20–23, 1984.

APPOINTMENTS

P. Becher was appointed Chairman of the Sosman Memorial Lecture Committee, Subcommittee on Show and Conference, of the American Welding Society.

J. Bentley was appointed Associate Professor, part-time, Department of Chemical, Metallurgical, and Polymer Engineering, University of Tennessee, Knoxville.

J. Bentley was reappointed Adjunct Professor of Materials Science, Vanderbilt University, Nashville, Tennessee, for a three-year term beginning with the fall 1983 semester.

A. Bleier served as group moderator of the U.S. Department of Energy meeting on Characterization and Behavior of Submicron Carbide and Nitride Powder, Albuquerque, New Mexico, February 26–March 2, 1984.

E. E. Bloom was appointed to the Metals Engineering Institute Committee of the American Society for Metals for a three-year term.

J. E. Cunningham was appointed a member (past Chairman) of the Advisory Technical Awareness Council of the American Society for Metals.

S. A. David was appointed Adjunct Associate Professor of Metallurgical and Materials Engineering in the School of Engineering, Department of Metallurgical and Materials Engineering, University of Pittsburgh, Pennsylvania.

B. E. Foster was appointed to serve as a member of the E7.01 Committee on Radiography of the American Society for Testing and Materials.

R. J. Gray was selected to judge an international photographic competition, Nikon's Small World Competition, at Nikon House in New York City, July 14, 1983.

D. O. Hobson was appointed Chairman of the newly formed Texture and Anisotropy Committee of the Materials Science Division of the American Society for Metals for a two-year term.

R. R. Judkins was appointed Vice-Chairman of The Metal Properties Council Phase Group VII (Materials for Liquefaction, Processes, Abrasion, and Slurry Erosion) of Subcommittee 9 (Materials for Fossil Fuel Conversion and Utilization).

E. A. Kenik was reappointed Adjunct Associate Professor, Department of Mechanical and Materials Engineering, Vanderbilt University, Nashville, Tennessee, for a three-year term beginning in September 1983.

W. J. **Lackey** was appointed a member of the American Ceramic Society Programs and Meetings Committee for a four-year term.

M. M. **Martin** was appointed a member of the American Society for Metals Membership Committee for a three-year term.

R. W. McClung was appointed Chairman of the Finance Committee to assist the U.S. Technical Advisory Group for the International Standards Organization Technical Committee 135 of the American Society for Testing and Materials.

R. W. **McClung** was selected to serve as a member of the Nominating Committee for the E7 Committee on Nondestructive Testing of the American Society for Testing and Materials.

A. J. **Moorhead** was appointed to serve as Chairman of the C3H Subcommittee on Show and Conference of the American Welding Society.

R. K. **Nanstad** was appointed Chairman of the Subcommittee on Thermal and Mechanical Effects of the Pressure Vessel Research Committee, Welding Research Council.

A. R. **Olsen** was appointed to serve as a member of the Subcommittee of the Reactor Operations Review Committee for the Oak Ridge Research Reactor for a one-year period.

P. S. **Sklad** was reappointed Adjunct Associate Professor, Department of Mechanical and Materials Engineering, Vanderbilt University, Nashville, Tennessee, for a three-year term beginning in September 1983.

P. S. **Sklad** was reappointed to the Education Committee of the Electron Microscopy Society of America as audiovisual coordinator from August 1983 to July 1984.

J. H. **Smith** was appointed to serve during 1983–84 as the Board of Directors representative to the Section Management and Membership Committee of the American Society for Nondestructive Testing.

J. H. **Smith** was appointed to the committee to select the recipient of the 1984 American Society for Nondestructive Testing Achievement Award.

C. J. **Sparks, Jr.**, was appointed a member of the Policy Advisory Board, National Synchrotron Light Source, Brookhaven National Laboratory.

G. M. **Stocks** was appointed a member of the U.S. Department of Energy's Research Computer Users Advisory Committee.

Appendix E

SEMINAR PROGRAM

Because effective communication is vital to scientific and technological advancement, the division sponsors and maintains an active seminar program to promote the exchange of ideas and the discussion of common problems among researchers working in the field of materials science and technology and allied disciplines. Most of the talks deal with scientific and engineering subjects and are presented by invited speakers from various organizations in North America and abroad. The actual number of talks scheduled in any given week varies but over the year averages slightly less than two per week.

The Seminar Program is administered by a committee appointed by division management. The Seminar Committee for the reporting period consists of J. A. Carpenter (chairman), J. P. Hammond, P. S. Sklad, and J. A. Horton.

The speakers and topics of seminars presented in the past 18 months are listed below. It is interesting that 37 of the 132 talks were made by individuals affiliated with institutions outside the United States. An alternative breakdown shows 57 talks by university faculty members and graduate students, 28 by representatives from industrial firms, and the balance from governmental and other research institutions. In function, the program achieves the desired objectives of maintaining close relationships with the university community and of enhancing the diffusion of knowledge.

B. R. Dewey, University of Wyoming, Laramie, "Finite Element Modeling of Ultrasonic Inspection of Weldments," January 6, 1983.

L. E. Willertz, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, "Elevated-Temperature Corrosion Fatigue Using Ultrasonic Techniques," January 12, 1983.

N. S. Stoloff, Rensselaer Polytechnic Institute, Troy, New York, "Ordered Alloys for Structural Applications," January 13, 1983.

G. R. Odette, University of California, Santa Barbara, "Helium Effects on Microstructural Evolution and Swelling," January 25, 1983.

G. R. Odette, University of California, Santa Barbara, "Modeling the Effects of Gas and Grain Boundary Microstructure on Mechanical Behavior in Several Environments," January 26, 1983.

C. B. Finch, Metals and Ceramics Division, ORNL, "CVD TiB_2 and Glimpses of South Africa," January 28, 1983.

J. Fong, National Bureau of Standards, Washington, D.C., "On-line Retrieval and Analysis of Materials Data for Critical Decision Making," February 7, 1983.

J. G. **Hamoosh**, Norton Company, Worcester, Massachusetts, "Modeling of Ceramic-Ceramic and Ceramic-Metal Joints," February 9, 1983.

M. **Stocks**, Metals and Ceramics Division, ORNL, "A Hitchhiker's Guide to SERC, Daresbury, Concentration Waves, Metallic Magnetism, and the Fumious Bandersnatch," February 11, 1983.

R. **Herschitz**, Cornell University, Ithaca, New York, "Atom Probe Field Ion Microscope Study of Solute Atom Segregation to Stacking Faults in Cobalt-Base Alloys and the Study of Radiation-Induced Precipitation in Tungsten-Rhenium Alloys," February 15, 1983.

W. **Lowe**, Stanford University, Stanford, California, "Structure and Superconductivity of Metallic Multilayers," February 15, 1983.

R. A. **Lula**, Consultant, formerly with Allegheny Ludlum Steel Corporation, "Recent Developments in Duplex Austentitic/Ferritic Stainless Steel," February 16, 1983.

R. **Chasnov**, University of Illinois, Urbana, "Structural Studies of Hydrides with Diffuse X-Ray Scattering," February 28, 1983.

S. **Antalovich**, University of Cincinnati, Ohio, "Fatigue Crack Propagation and Low-Cycle Fatigue in Nickel-Base Super Alloys," March 11, 1983.

W. K. **Choo**, Korea Advanced Institute of Science and Technology, Seoul, South Korea, "Phase Stability of Fe-Mn-Al-C Alloys," March 14, 1983.

G. W. **Wellman**, University of Kansas, Manhattan, "Application of the CTOD Test Method to the Fracture Resistance Design of Pressure Vessels," March 17, 1983.

J.-G. **Wang**, Cornell University, Ithaca, New York, "Super Plastic Flow in Glass-Ceramics Under Multiaxial Loading," March 17, 1983.

W. A. **Jemian**, Auburn University, Auburn, Alabama, "Welding and Weldability Aluminides," March 21, 1983.

Y. **Fu**, University of California, Berkeley, "Microcrack Toughening of Ceramics," March 21, 1983.

M. **Böhmer**, Institute for Materials Research, West German Space Agency, Cologne, Federal Republic of Germany, "German Advanced Heat Engine Program and Ceramics Development," March 23, 1983.

M. K. **Miller**, U.S. Steel Research Laboratory, Monroeville, Pennsylvania, "Application of the Atom Probe to Phase Transformations," March 28, 1983.

J. **Narayan**, Solid State Division, ORNL, "Laser Annealing of Ceramics," March 29, 1983.

D. W. **Richerson**, Garrett Turbine Engine Company, Phoenix, Arizona, "Advanced Gas Turbine Engine Program: A Review of and Status Report on Structural Ceramic Technology at Garrett," April 5, 1983.

R. L. **Coble**, Massachusetts Institute of Technology, Cambridge, "Reanalysis of the 'Rules' for Sintering to High-Density Paradigms," April 6, 1983.

A. E. Pasto, GTE Laboratories, Waltham, Massachusetts, "Microstructural Effects Influencing Strength of Silicon Nitride," April 8, 1983.

E. A. Kenik, Metals and Ceramics Division, ORNL, "Shared Research Equipment Program or How to Get Your SHaRE," April 8, 1983.

G. Grimvall, Royal Institute of Technology, Stockholm, Sweden, "High-Temperature Resistivity and a New Thermal Defect," April 8, 1983.

W. Dobson, Teledyne Engineering Services, Waltham, Massachusetts, "Testing and Analysis of Materials at Cryogenic Temperatures as Low as 4 K," April 12, 1983.

C. R. Houska, Virginia Polytechnic Institute and State University, Blacksburg, "X-Ray Diffraction Methods for Investigations of Near-Surface Regions of Solids," April 14, 1983.

C. J. Altstetter, University of Illinois, Urbana, "Hydrogen Embrittlement of Stainless Steel," April 14, 1983.

J. Bilello, State University of New York at Stony Brook, "Applications of Synchrotron X-Ray Topography to the Study of Deformation and Fracture of Materials," April 14, 1983.

M. L. Sentella, Olin Corporation, New Haven, Connecticut, "Reheated Microstructure and Hot Rolling Behavior of Austenite," April 14, 1983.

K. U. Snowden, Australian AEC Research Establishment, Lucas Heights, New South Wales, "Creep Cavities, Cracks, and Conundrums," April 25, 1983.

W. C. Moshier, Massachusetts Institute of Technology, Cambridge, "Effect of Heat Treatment on Fatigue Crack Growth of Inconel 600," April 28, 1983.

S. Somiya, Tokyo Institute of Technology, Yokohama, Japan, "Synthesis of Ceramic Powders," April 29, 1983.

S. M. Wiederhorn, National Bureau of Standards, Washington, D.C., "Structural Reliability of Ceramics," May 2, 1983.

I. French, CSIRO, Australia, "Welding Research at Commonwealth Scientific and Industrial Research Organization of Australia," May 11, 1983.

J. A. Panitz, Sandia National Laboratories, Albuquerque, New Mexico, "The Imaging Atom-Probe," May 11, 1983.

R. Giddings, General Electric Research and Development Center, Schenectady, New York, "Development and Status of Beta Silicon Carbide," May 18, 1983.

C. Johnson, General Electric Research and Development Center, Schenectady, New York, "Statistics of Fracture in Brittle Materials" May 31, 1983.

L. J. Schioler, Army Materials and Mechanics Research Center, Watertown, Massachusetts, "Structure-Conductivity Relations in the Fast-Ion Conducting NASICON Solid Solution System," June 1, 1983.

H. Moeller, Babcock & Wilcox Research Center, Lynchburg, Virginia, "Study of Crack Growth in Ceramics Using Acoustic Emission Location Techniques," June 6, 1983.

T. L. Anderson, Colorado School of Mines, Golden, and National Bureau of Standards, "Fracture of Steels in the Ductile-to-Brittle Transition Region," June 7, 1983.

B. A. Nagaraj, GEC Power Engineering, Leister, England, "Application of High-Temperature Heat Exchangers to Coal-Burning Gas Turbine Systems," June 9, 1983.

P. Sutor, Midwest Research Institute, Dayton, Ohio, "Friction and Wear Testing of Bearing Ceramics at High Temperature," June 29, 1983.

J. McGowan, University of Alabama, Tuscaloosa, "A Microprocessor-Based System for Determining Near-Threshold Fatigue C. ck Growth Rates," July 7, 1983.

D. D. Button, Norton Company, Worchester, Massachusetts, "Sintering of Glass," July 7, 1983.

M. A. Janney, Kennametal, Inc., Latrobe, Pennsylvania, "Plasticity of Ceramic Systems," July 8, 1983.

J. H. Schneibel, Metals and Ceramics Division, ORNL, "Grain Boundary Sliding in Nickel—The Influence of Small Alloying Additions," July 8, 1983.

S. Verma, Illinois Institute of Technology Research Institute, Chicago, Illinois, "High-Temperature Corrosion of Commercial Alloys in Coal Gasification Environments," July 11, 1983.

S. Nutt, National Bureau of Standards, Washington, D.C., "Microstructure of SiC-Al Composites," July 11, 1983.

W. L. Hawkins, The Plastics Institute of America, Hoboken, New Jersey, "Recycling of Plastics from Scrapped and Shredded Automobiles," July 11, 1983.

J. Sankar, North Carolina State University, Raleigh, "The Effect of Submerged Arc Welding Variables on the Structure of Mechanical Behavior of Pressure Vessel Steel Weldments," July 20, 1983.

J. G. Luckman, Exxon Research and Engineering Company, Linden, New Jersey, "Chemisorption and Gas-Solid Reaction Kinetics in Carburization and Oxidation," July 20, 1983.

C. Wassilew, Kernforschungszentrum, Karlsruhe, Federal Republic of Germany, "Twin Planes in FCC Metals as Related to Helium Embrittlement," July 26, 1983.

D. F. Pedraza, University of Connecticut, Storrs, "The Martensitic Transformation in Ferrous Alloys," August 4, 1983.

G. Czjzek, Kernforschungszentrum, Karlsruhe, Federal Repulic of Germany, "Structural Studies of Amorphous Solids by Mossbauer Spectroscopy," August 8, 1983.

J. E. Gould, Carnegie-Mellon University, Pittsburgh, Pennsylvania, "The Effect of Composition and Weld Process on the Titanium Alloy Welds," August 8, 1983.

P. Weinberger, University of Vienna, Austria, "Electronic States of Actinides and Actinide Compounds," August 10, 1983.

J. E. Allison, Brown Boveri, Switzerland, "Fatigue Crack Growth in Titanium Alloys," August [illegible], 1983.

R. E. Stoller, University of California, Santa Barbara, "Modeling the Influence of Transmutant Helium on Neutron-Irradiated Austenitic Stainless Steel," August 18, 1983.

A. Lawley, Drexel University, Philadelphia, Pennsylvania, "Metal Matrix Composites—Status and Potential," August 22, 1983.

W. C. Oliver, United Technology Research Center, Sunnyvale, California, "The Influence of Surface Image Forces on Very Shallow Hardness Measurements," August 24, 1983.

P. B. Allen, State University of New York at Stony Brook, "Quasi-Particle and Non-Quasi-Particle Transport in Solids," August 24, 1983.

T. Hehenkamp, Institut für Metallphysik, Universitat Göttingen, Federal Republic of Germany, "Vacancy Formation and Diffusion in Alpha-Range Alloys," August 25, 1983.

D. Post, Y-12 Development, Y-12 Plant, Oak Ridge, Tennessee, "Methods Used to Fabricate Components from Composite Materials," August 25, 1983.

E. M. Schulson, Dartmouth College, Hanover, New Hampshire, "Strength and Ductility of Polycrystalline Nickel Aluminides (Ni_3Al and NiAl)," August 29, 1983.

P. Lamparter, Max-Planck Institut für Metallforschung, Stuttgart, Federal Republic of Germany, "Atomic Structure of Metallic Glasses," September 1, 1983.

G. Golliher, Metals and Ceramics Division, ORNL, "How Big Am I Now," September 7, 1983.

D. M. Nicholson, Oak Ridge Associated Universities, Oak Ridge, Tennessee, "Self-Consistent Total Energy Calculations with the Quadratic KKR," September 9, 1983.

D. F. Adams, University of Wyoming, Laramie, "Analytical Predictions and Experimental Measurements of Composite Materials Properties," September 12, 1983.

J. Hack, Southwest Research Institute, San Antonio, Texas, "Hydrogen-Assisted Sustained Load Cracking in Structural Alloys," September 13, 1983.

B. L. Gyorffy, H. H. Wills Physics Laboratory, University of Bristol, England, "Theory of Magnetic Phase Transitions in Metals," September 14, 1983.

J. K. Tien, Columbia University, New York, "Alloy Redesign of Superalloy," September 15, 1983.

K. Klarin, National Swedish Board for Technical Development, Stockholm, Sweden, "Metallic Materials Research in Sweden," September 22, 1983.

H. Ullmaier, **W. Kesternich**, and **P. Batfalsky**, Institut für Festkörperforschung, Kernforschungsanlage, Jülich, Federal Republic of Germany, "Recent Research on Helium Effects on Microstructure and Properties," September 27, 1983.

D. Kaletta, Kernforschungszentrum, Karlsruhe, Federal Republic of Germany, "Fusion Materials Research at Karlsruhe," September 27, 1983.

A. J. Pindor, University of Toronto, Canada, "KKR-CPA Calculations of the Electronic Structure of Hydrides," September 28, 1983.

F. A. List III, Cornell University, Ithaca, New York, "The Oxidation of Carbon on Nickel Surfaces," October 3, 1983.

D. S. Tucker, Atlantic Richfield, Chatsworth, California, "Transformation Mechanism for Spherical Alumina Powders Precipitated from a Sulphate Solution," October 5, 1983.

M. Schlüter, Bell Laboratories, Murray Hill, New Jersey, "Quantum Theory of Localized Defect," October 5, 1983.

J. Muller, Institut für Festkörperforschung, Kernforschungsanlage, Jülich, "Cluster Study of the Interaction of an H_2O Molecule with the Al(100) Surface," October 19, 1983.

M. Bennett, Atomic Energy Research Establishment, Harwell, England, "New Techniques for Examining Micron-Thick Oxide Scales," October 24, 1983.

J. F. Golden, E. Leitz, Inc., Rockleigh, New Jersey, "Current Perspectives on Image Analysis—Its Capabilities and Applications," October 26, 1983.

D. J. Griffiths, Oregon State University, Corvallis, "Small-Angle X-Ray Scattering in Amorphous TbCu," October 27, 1983.

D. J. Rowcliffe, Stanford Research Institute, Stanford, California, "Structure and Deformation Behavior of the Transition Metal Carbides," October 31, 1983.

D. C. Cranmer, Massachusetts Institute of Technology, Cambridge, "Friction and Wear of Monolithic Ceramics," October 31, 1983.

Y. Ohrn, University of Florida, Gainesville, "An Alternative Description of Molecular Electronic Spectra Using Electron Pair Functions," November 4, 1983.

D. G. Morris, Atlas Copco Corporate Research Laboratory, Institut Cerac, Switzerland, "Some Developments in Rapid Solidification Technology for Mechanical Applications," November 7, 1983.

J. Lankford, Southwest Research Institute, San Antonio, Texas, "Fracture and Deformation of Partially Stabilized Zirconia," November 8, 1983.

R. A. Page, Southwest Research Institute, San Antonio, Texas, "Study of Creep Cavitation in Al_2O_3 and SiC by SANS," November 8, 1983.

E. Kisker, Kernforschungsanlage, Jülich, Federal Republic of Germany, "Spin-Split Electronic States in Fe and Ni and Their Temperature Dependence," November 14, 1983.

J. B. Posthill, University of Oxford, England, "Precipitation Reactions in the 90 W-5 Ni-5 Fe Heavy-Alloy System," November 21, 1983.

H. G. Corbett, Metals and Ceramics Division, ORNL, "Behind the Iron Curtain—Personal Glimpses of Czechoslovakia," November 22, 1983.

Y. Shimazaki, Georgia Institute of Technology, Atlanta, "Steady-State Frictional Behavior of Thin Films," December 5, 1983.

J. M. Sanchez, Henry Krum School of Mines, Columbia University, New York, "Modeling of Alloy Phase Equilibrium," December 14, 1983.

M. Mendiratta, Systems Research Laboratories, Dayton, Ohio, "Flow and Fracture Behavior of Iron Aluminides," January 10, 1984.

T.-L. Mah, Systems Research Laboratories, Dayton, Ohio, "Ceramic Fiber-Reinforced Ceramic Matrix Composites," January 10, 1984.

J. Haggerty, Massachusetts Institute of Technology, Cambridge, "Powder and Thin-Film Synthesis by Laser-Induced Gas-Phase Reactions," January 12, 1984.

J. Stevens, Stanford University, Stanford, California, "Creep and Fracture Behavior of MA 754 at Elevated Temperature," January 16, 1984.

B. Carter, Cornell University, Ithaca, New York, "Phase and Grain Boundaries in Ceramics," January 17, 1984.

C. R. Brooks, University of Tennessee, Knoxville, "Physical Metallurgy of Nickel and Molybdenum Alloys," February 22, 1984.

O. Buyukozturk and **E.-S. Chen**, Massachusetts Institute of Technology, Cambridge, "Three-Dimensional Finite-Element Analysis of Thermomechanical Stresses in Brittle Materials (Refractories for Coal Gasifiers)," March 22, 1984.

D. G. Pettifor, Imperial College of Science and Technology, London, England, "The Structural Stability of Metals and Compounds," April 2, 1984.

F. Gautier, Université Louis Pasteur, Strasbourg, France, "Electronic Structure, Order, and Stability of Transition Metal Alloys and Compounds," April 4, 1984.

R. Raj, Cornell University, Ithaca, New York, "Sintering Behavior of Bimodal Powder Compact," April 5, 1984.

R. G. Jordan, University of Birmingham, England, "Use of Angle-Resolved UV Photoelectron Spectroscopy in the Study of Alloys," April 6, 1984.

P. J. Alberry, Central Electricity Generating Board, Marchwood Engineering Laboratory, Marchwood, England, "Prediction of HAZ Structure and Hardness for PWR Repair Welds," April 13, 1984.

R. L. Berger, University of Illinois, Urbana, "A Potpourri of Observations on the Characteristics of Hydrofracture Grouts," April 26, 1984.

H. Hieber, Philips GmbH Research Laboratory, Hamburg, Federal Republic of Germany, "Degradation of Hybrid Interconnections," May 2, 1984.

F. W. Clinard, Los Alamos National Laboratory, Los Alamos, New Mexico, "Radiation Effects on Ceramics," May 4, 1984.

Y. Tajima, NGK Spark Plug Co., Ltd., Aichi, Japan, "Effects of Substituting AlN for Al_2O_3 on the Sintering Behavior and Properties in the Si_3N_4-Al_2O_3 System," May 8, 1984.

Y. Katayama, NGK Spark Plug Co., Ltd., Aichi, Japan, "Strength/Flaw-Size Relationship for Sintered Si_3N_4," May 8, 1984.

J. Budai, Cornell University, Ithaca, New York, "X-Ray Diffraction Studies of Grain Boundaries and of Hexatic Order in Liquid Crystals," May 10, 1984.

P. Von der Hardt, Joint Research Center, Petten, Netherlands, "Fusion-Materials Irradiation and Vessel Replacement in the High Flux Reactor in Petten, Netherlands," May 15, 1984.

J. B. Wagner, Jr., Center for Materials Science, Arizona State University, Tempe, "Studies on the Sulfidation of Metals," May 24, 1984.

J. A. Carpenter, Metals and Ceramics Division, ORNL "Personal Glimpes of India and Nepal," June 1, 1984.

W. E. Lee, Case Western Reserve University, Cleveland, Ohio, "A TEM Study of Heavy-Ion Radiation Damage in Alpha-Alumina With and Without Helium Preimplantation," June 11, 1984.

J. H. Evans, Atomic Energy Research Establishment, Harwell, England, "Precipitation of Helium in Metals," June 15, 1984.

C. H. Henager, Jr., Battelle Pacific Northwest Laboratory, Richland, Washington, "Irradiation Creep Mechanisms in Pure Nickel at Low Fluence," June 15, 1984.

A. Pasto, GTE Laboratories, Waltham, Massachusetts, "Causes and Effects of Iron-Bearing Inclusions in Silicon Nitride," June 15, 1984.

K. P. Singh. Indian Institute of Technology, Kanpur, India, "Oxidation and Mechanical Behavior of Cr-Mo Steels," June 19, 1984.

D. P. Pope, University of Pennsylvania, Philadelphia, "A Strengthening Mechanism in Ordered Intermetallic Alloys," June 21, 1984.

R. McElroy, Atomic Energy Research Establishment, Harwell, England, "Irradiation Creep and Growth During Proton Bombardment," June 25, 1984.

P. T. Thornton was appointed Vice President–Membership of the Association of Information Systems Professionals for the 1983–84 term.

F. W. Wiffen was appointed a member of the *Journal of Metals* Advisory Board, representing the Nuclear Metallurgy Committee of The Metallurgical Society of AIME.

Appendix F

INFORMATION MEETING AND ADVISORY COMMITTEE

The next divisional information meeting and concurrent advisory committee review will occur December 12 through 14, 1984. An overview of the general condition of the division and reports of technical progress, changes in thrust and direction, and new initiatives on the programmatic effort will be presented.

The Advisory Committee to the Metals and Ceramics Division currently consists of six members appointed by the laboratory director. Members are appointed for staggered four-year terms so that two new members replace two retiring members. The committee meets as a body during the information meeting and review, and each member visits the division separately during the 18-month period. The main function of the committee is to review divisional ongoing research and development activities and facilities and to render independent judgments on the general condition, ability of staff, and progress in various operations and missions of the division. Members are chosen from governmental, industrial, educational, and research institutions in the United States and are selected on the basis of demonstrated ability in management, research, and technology. Members of the 1984 Metals and Ceramics Division Advisory Committee are listed below.

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Appendix G

PUBLICATIONS

Compiled by Faye Roseberry

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D. W. Yarbrough, J. H. Wright, D. L. McElroy, and T. F. Scanlan, "Settling of Loose-Fill Insulations Due to Vibration," pp. 7[illegible]–14 in *Thermal Insulation, Materials, and Systems for Energy Conservation in the '80s,* ASTM [illegible].P 789, ed. F. A. Govan, D. M. Greason, and J. D. McAllister, American Society for Testing and Materials, Philadelphia, 1983.

M. H. Yoo and H. Trinkaus, "Crack and Cavity Nucleation at Interfaces During Creep," pp. 547–61 in *Thermal Conductivity 17,* proceedings of 17th International Conference held in Gaithersburg, Md., on June 15–19, 1981, ed. J. G. Hust, Plenum Press, New York, April 1983.

C. S. Yust, "Low Speed Sliding Damage in TiB_2-Ni Composites," pp. 167–73 in *Wear of Materials 1983,* ed. K. C. Ludema, American Society of Mechanical Engineers, New York, 1983.

C. S. Yust and E. L. Long, Jr., "Optical and Electron Microscopy of WC-Co Alloys," *Am. Ceram. Soc. Bull.* **62**(9), 1039–44 (September 1983).

Appendix H

PRESENTATIONS AT TECHNICAL MEETINGS

Compiled by Faye Roseberry

Eighth European Thermal Physical Properties Meeting, Baden Baden, West Germany, October 2–7, 1982:

D. L. McElroy,* G. Neuer, and R. Tye, "Thermophysical Properties of Industrial Insulators"

American Society for Testing and Materials Committee C16 and N.R.C.C. Seminar on Guarded Hot Plate, Quebec, Canada, October 7–8, 1982:

D. L. McElroy,* R. S. Graves, D. W. Yarbrough, and J. P. Moore. "A Flat Insulation Tester That Uses an Unguarded Nichrome Screen Wire Heater"

Materials Research Society 1982 Meeting, Boston, Massachusetts, November 1–4, 1982:

A. G. Dhere, R. J. DeAngelis,* J. Bentley, and P. J. Reucroft, "Structural Characteristics of Cobalt Particles in a 9.5% Co–ZSM-5 Catalyst"

Symposium on First Principles Calculations of Atomic Arrangements, Lattice Vibrations, and Magnetism in Metals, Institute of Physics, University of London, England, December 20–22, 1982:

B. L. Gyorffy, J. Kollar, A. J. Pindor, J. Staunton,* G. M. Stocks, and H. Winter, "Spin-Polarized Band Theory at Finite Temperatures"

P. Weightman,* P. T. Andrews, G. M. Stocks, and H. Winter, "A Study of the Band Structures of Cu_cPd_{1-c} and Ag_cPd_{1-c} Alloys by a Combination of Auger Spectroscopy and SCF-KKR-CPA Calculations"

Seminar, Arizona State University, Tempe, January 14, 1983:

L. K. Mansur, "Mechanisms of Radiation Effects in Structural Materials"

Seventh Annual Conference on Ceramics and Advanced Materials, American Ceramic Society, Cocoa Beach, Florida, January 16–20, 1983:

E. L. Long, Jr.,* and C. S. Yust, "Evaluation of Pressure Letdown Valve Trim Materials Used in Coal Liquefaction Plants"

A. J. Moorhead,* P. F. Becher, and R. J. Lauf, "Fracture Mechanics Tests of Dispersed Metal-Toughened Aluminas"

Nuclear Regulatory Commission–Industry Steam Generator Tube Degradation Seminar, Palo Alto, California, February 9, 1983:

C. V. Dodd, "Multifrequency Eddy-Current Development for In-Service Inspection of Steam Generator Tubing"

Seminar, Mechanical Engineering Department, College of Engineering, University of Kentucky, Lexington, February 10, 1983:

R. W. McClung, "An Overview of Nondestructive Testing"

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*Speaker.

12th Annual Symposium on Vacuum Science and Technology, Clearwater Beach, Florida, February 14–16,1983:

R. E. Clausing, "Modification of Surfaces in Tokamak Fusion Devices by Exposure to Hydrogen Plasmas"

Seminar, Department of Metallurgical, Chemical, and Polymer Engineering, University of Tennessee, Knoxville, February 22, 1983:

C. J. McHargue, "Ion Implantation Treatment of Ceramic Surfaces"

Seminar, Department of Metallurgical, Chemical, and Polymer Engineering, University of Tennessee, Knoxville, March 1, 1983:

H. L. Yakel, "Estimating Site-Occupation Parameters in Sigma Phases and Tau Carbides"

112th Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Atlanta, Georgia, March 6–10, 1983:

J. Bentley* and E. A. Kenik, "Application of Analytical and High-Voltage Electron Microscopy to Defect and Phase Identification in Materials"

I-Wei Chen and M. H. Yoo,* "Nucleation of Intergranular Cavities During Creep"

A. DasGupta* and C. T. Liu, "A Study of the Order-Disorder Transformation in $(Ni_{70}Fe_{30})_3(V_{98-x}Ti_2Al_x)$ by Differential Scanning Calorimetry and X-Ray Diffraction"

C. T. Liu, "Alloying Effects on Ordered Intermetallic Alloys"

J. H. Schneibel* and P. M. Hazzledine, "The Role of Coble Creep and Interface Control in Superplastic Sn-Pb Alloys"

J. H. Schneibel,* G. F. Petersen, and C. L. White, "The Improvement of Creep Ductility of Ni-20% Cr by Trace Additions of Zr"

C. J. Sparks, Jr., "Synchrotron Radiation Applied to Materials Science"

L. D. Stephenson,* J. Bentley, R. B. Benson, Jr., and J. Hirvonen, "Analytical Electron Microscopy of Aluminum Implanted with Molybdenum"

J. M. Vitek* and S. A. David, "Aging Behavior of 308 Stainless Steel Weld Filler Metal"

M. H. Yoo,* J. C. Ogle, I-Wei Chen, and J. H. Schneibel, "Deformation-Induced Grain Boundary Cavitation—A Small-Angle Neutron Scattering Study"

Meeting of the Advisory Technical Awareness Council, American Society for Metals, Cleveland, Ohio, March 16, 1983:

J. E. Cunningham, "Recent Developments in Graphite"

American Physical Society Meeting, Los Angeles, California, March 21–25, 1983:

W. H. Butler* and G. M. Stocks, "Hall Coefficient of Ag_xPd_{1-x} Alloys"

A. Gonis,* G. M. Stocks, and W. H. Butler, "Local Environment Fluctuations and Densities of States in Substitutionally Disordered Alloys"

D. M. Kroeger,* C. C. Koch, and J. O. Scarbrough, "Correlations Among Crystallization Behavior, Physical Properties, and the Equilibrium Phase Diagram in Glassy Zr-Ni"

D. M. Nicholson,* A. Chowdary, and L. Schwartz, "Structure Dependence of Electronic States in Amorphous Metals"

G. S. Painter* and F. W. Averill, "Transition Metal Dimer Studies Within the Local Spin Density Approximation (LSDA) Using an Augmented Gaussian Orbital Approach"

F. J. Pinski* and G. M. Stocks, "Electronic Structure of Fe_cNi_{1-c} Alloys"

G. M. Stocks* and B. L. Gyorffy, "Fermi Surface Driven Concentration Waves in Cu_cPd_{1-c} and Ag_cPd_{1-c} Random Alloys"

G. M. Stocks* and H. Winter, "Charge Self-Consistency in Random Alloys"

Technical Seminar on Dynamic Young's Modulus Measurements, sponsored by ASTM Committee E-28 on Mechanical Testing, Louisville, Kentucky, March 24, 1983:

C. R. Kennedy, "Elastic Constants of Graphite"

Meeting on Materials Problems in the Energy Business, sponsored by the American Society for Metals, Rocky Mountain Chapter, and the Colorado School of Mines, Golden, Colorado, March 24–25, 1983:

D. N. Braski* and S. A. David, "$(Fe,Ni)_3V$ Ordered Alloys for Fusion Reactor First Wall"

J. R. Weir, Jr., "Materials and Our Energy Future"

Third Workshop on Metallic Magnetism, Institut von Laue Langevin, Grenoble, France, March 25–26, 1983:

B. L. Gyorffy,* J. Kollar, A. J. Pindor, J. Staunton, G. M. Stocks, and H. Winter, "Spin Polarized Band Theory at Finite Temperatures"

Technical Meeting of Golden Gate Chapter, American Society for Metals, Berkeley, California, April 4, 1983:

J. M. Vitek, "Solidification and Microstructure of Rapidly Solidified Austenitic Stainless Steels"

Fast Reactor Exchange Meeting, Brighton, England, April 10–15,1983:

M. L. Grossbeck and E. E. Bloom (presented by A. F. Rowcliffe), "In-Reactor Uniaxial Fracture Strain of 20%-Cold-Worked Type 316 Stainless Steel"

Steam Generator Users Group Meeting, Electric Power Research Institute, Palo Alto, California, April 11, 1983:

C. V. Dodd, "Multifrequency Eddy-Current Development for In-Service Inspection of Steam Generator Tubing"

Seminar, University of Virginia, Charlottesville, April 11, 1983:

E. E. Bloom, "Radiation Damage to Fusion Reactor Materials"

International Conference on Dimensional Stability and Mechanical Behavior of Irradiated Metals and Alloys, Brighton, England, April 11–13, 1983:

K. Farrell (presented by L. K. Mansur), "Response of Aluminum and Its Alloys to Exposure in the High Flux Isotope Reactor"

M. L. Grossbeck and E. E. Bloom (presented by A. F. Rowcliffe), "In-Reactor Uniaxial Fracture Strain"

L. K. Mansur* and W. A. Coghlan, "Relationships of Irradiation Creep to Swelling Implicit in the Theories of These Processes"

A. F. Rowcliffe* and E. H. Lee, "The Stability of the MC Phase in a Stainless Steel Irradiated in Various Environments"

International Conference on Wear of Materials, sponsored by the American Society of Mechanical Engineers, Reston, Virginia, April 11–14, 1983:

C. S. Yust, "Low Speed Sliding Damage in TiB_2-Ni Composites"

Meeting of Study Group on Critical and Strategic Materials, Idaho National Engineering Laboratory, Idaho Falls, Idaho, April 12–13, 1983:

C. J. McHargue, "Basic Energy Sciences-Materials Sciences Program Elements Dealing with Strategic-Critical Materials at Oak Ridge National Laboratory"

C. J. McHargue, "Chromium Substitution in Alloys"

C. J. McHargue, "Opportunities for Surface Modification—Ceramics"

Symposium on Advances in Materials Analysis, American Society for Metals, Oak Ridge Chapter, Oak Ridge, Tennessee, April 15, 1983:

J. Bentley, "Electron Diffraction Techniques in an Analytical Electron Microscope"

C. J. Sparks, Jr., "Synchrotron X-Radiation Applied to Materials Characterization"

Seminar, Massachusetts Institute of Technology, Cambridge, April 15, 1983:

M. H. Yoo, "Precipitation and Cavitation Studies Using Small-Angle Neutron Scattering"

Seminar, International Business Machines, Yorktown Heights, New York, April 18, 1983:

M. H. Yoo, "Precipitation and Cavitation Studies Using Small-Angle Neutron Scattering"

Seminar, Berkeley Nuclear Laboratories, Berkeley, England, April 19, 1983:

L. K. Mansur, "Progress in the Theoretical Understanding of Helium Interaction with Microstructural Evolution"

Seminar, Atomic Energy Research Establishment, Harwell, England, April 20, 1983:

L. K. Mansur, "Progress in the Theoretical Understanding of Helium Interaction with Microstructural Evolution"

85th Annual Meeting of the American Ceramic Society, Chicago, Illinois, April 24–27, 1983:

P. F. Becher,* M. K. Ferber, and B. G. Koepke, "Slow Crack Growth Behavior in Anisotropic Polycrystalline Ceramics"

J. Bentley,* P. Angelini, and P. F. Becher, "Analytical Electron Microscopy of Al_2O_3 Toughened with Y-Doped ZrO_2"

C. H. Carter, Jr.,* R. F. Davis, and J. Bentley, "Kinetics and Mechanisms of Creep in CVD Silicon Carbide"

G. W. Clark* and P. F. Becher, "Eutectic-Like Morphology and Fracture Toughness of $ZrO_2(Y_2O_3)$-ZrB_2"

A. DasGupta* and Y. T. Chou, "Flux Pinning by Surfaces and Interfaces in Type-II Superconductors"

M. K. Ferber* and P. F. Becher, "Temperature Dependence of Static Fatigue in Polycrystalline BeO"

M. K. Ferber and V. J. Tennery,* "Analysis of the Corrosion Products Formed from Reactions Between Silicon Carbide and a Fluid Coal Slag"

L. A. Harris,* C. R. Kennedy, and F. P. Jeffers, "A Study of Silicon Carbide Powder Agglomerates"

F. J. Homan* and M. J. Kania, "Particle Design and Fabrication Influences on HTGR Fuel Performance"

C. J. McHargue and C. S. Yust,* "Lattice Modifications in Ion-Implanted Ceramics"

D. P. Stinton,* E. W. McDaniel, and H. O. Weeren, "Detailed Characterization of Hydrofracture Grouts Revealed No Migration of Radionuclides"

G. C. Wei, "Synthesis and Characterization of SiC Powder"

64th Annual American Welding Society Meeting, Philadelphia, Pennsylvania, April 24–29, 1983:

S. A. David,* C. T. Liu, D. N. Braski, and G. M. Goodwin, "Welding and Associated Phase Transition in Ductile Long-Range-Ordered Alloys"

R. L. Klueh* and J. F. King, "A Simple Test for Dissimilar-Metal Welds"

V. K. Sikka,* J. F. King, and V. Biss, "Weldability and Microstructure of Modified 9 Cr-1 Mo Steel"

J. M. Vitek* and S. A. David, "The Aging Behavior of Types 308 and 308CRE Stainless Steel Weld Metal"

Fifth Topical Meeting on the Technology of Fusion Energy, Knoxville, Tennessee, April 26–28, 1983:

J. H. DeVan* and P. F. Tortorelli, "Materials Compatibility for a Fusion-Fission Hybrid Reactor Design"

R. W. McClung,* K. V. Cook, C. V. Dodd, and J. H. Smith, "Nondestructive Testing of Metallic Sheath for Superconducting Cable"

Meeting of the National Board of the American Society of Mechanical Engineers, Vancouver, British Columbia, Canada, May 2, 1983:

P. Patriarca, "Advances in the U.S. Liquid Metal Fast Breeder Reactor Program"

Seminar, University of California, Santa Barbara, May 2, 1983:

J. Bentley, "Modern Electron Diffraction Techniques"

Meeting of the American Society for Metals, Birmingham Chapter, Birmingham, Alabama, May 3, 1983:

R. J. Gray "Novel Metallographic Techniques for Analyses of Microstructures"

Electrochemical Society High-Temperature Materials Chemistry Conference, San Francisco, California, May 8–13, 1983:

R. J. Lauf* and J. B. Bates, "Ceramic-Metal Solid Electrolytes"

R. J. Lauf* and L. A. Harris, "Behavior of Mineral Matter During Coal Combustion"

C. T. Liu,* C. C. Koch, and C. L. White, "Preparation of Ductile Nickel Aluminides for High-Temperature Uses"

Meeting of American Society for Nondestructive Testing, Oak Ridge Section, Oak Ridge, Tennessee, May 10, 1983:

R. W. McClung, "Recent Nondestructive Testing Activities at Oak Ridge National Laboratory"

Informal workshop sponsored by the American Society for Testing and Materials Committee E9.08 on Recommended Practice E600, Louisville, Kentucky, May 10, 1983:

R. W. Swindeman, "Effect of Specimen Geometry on Low-Cycle Fatigue Behavior of Steels"

American Society for Testing and Materials Spring Meeting, Louisville, Kentucky, May 11, 1983:

K. C. Liu* and M. L. Grossbeck, "Fatigue Testing of Irradiated Specimens at Elevated Temperature and in High Vacuum"

Seminar, University of Tennessee Veterinary Teaching Hospital, College of Veterinary Medicine, University of Tennessee, Knoxville, May 16, 1983:

R. J. Gray, "A Metallurgical Survey of the Causes of Failed Implants from the Human Body"

Fusion Technology Course, Department of Nuclear Engineering, University of Tennessee, Knoxville, May 16–18, 1983:

J. L. Scott, "Materials Problems"

Leco Corporation Symposium on Metallography in Failure Analysis, Fort Lauderdale, Florida, May 19–20, 1983:

R. S. Crouse, "Electron Beam Microanalysis and Failure Studies"

R. J. Gray, "Metallographic Studies of Failed Implants from the Human Body"

Meeting of German Society for Metals, Erlangen, Germany, May 24–27, 1983:

G. L. Copeland* and J. L. Snelgrove, "Post Irradiation Evaluation of Irradiated High-U-Loaded U_3O_8-Al Fuel Plates"

Second International Conference on Radiation Effects in Insulators, Albuquerque, New Mexico, May 30–June 3, 1983:

B. R. Appleton,* N. Naramoto, C. W. White, O. W. Holland, C. J. McHargue, G. Farlow, J. Marayan, and J. M. Williams, "Ion Implantation, Ion Beam Mixing, and Annealing Studies of Metals in Al_2O_3, SiC, and Si_3N_4"

C. J. McHargue,* P. S. Sklad, P. Angelini, and M. B. Lewis, "Microstructure and Properties of TiB_2 Implanted with 1 MeV Nickel"

P. S. Sklad, P. Angelini, M. B. Lewis, J. T. Houston, and C. J. McHargue,* "Analytical Electron Microscope Observations of the Microstructure of TiB_2 Implanted with 1 MeV Nickel"

Department of Energy Symposium on Electroslag Component Casting, Morgantown, West Virginia, June 1–2, 1983:

R. L. Heestand, "Description of Electroslag Processes (Remelting, Welding, and Casting)"

R. R. Judkins, "The Electroslag Component Casting Project Plan"

V. K. Sikka, "Mechanical Properties of Electroslag Castings"

Conference on Crack Tip Structure and Processes, National Bureau of Standards, Washington, D.C., June 6–8, 1983:

M. H. Yoo,* H. Trinkaus, and I-W. Chen, "Cavity Nucleation During High-Temperature Deformation"

First Annual Meeting of Building Thermal Envelope Coordinating Council, Washington, D.C., June 7, 1983:

T. S. Lundy, "Status of the National Program for 'Building Thermal Envelope Systems and Insulating Materials (BTESIM)'"

57th Colloid and Surface Science Symposium, University of Toronto, Toronto, Ontario, Canada, June 12–15, 1983:

P. J. Reucroft,* R. J. DeAngelis, A. G. Dhere, and J. Bentley, "Metal-Support Interactions in Dispersed Metal Catalysts"

American Nuclear Society Spring Meeting, Detroit, Michigan, June 12–17, 1983:

R. G. Berggren* and F. W. Stallman, "Statistical Analysis of Pressure Vessel Steel Embrittlement Data"

W. P. Eatherly* and C. B. Engle, "Recent Developments in Graphite for HTGR Applications"

M. J. Kania* and F. J. Homan, "Irradiation Performance of LEU Fuel Particle Designs"

International Symposium on Structure-Property Relationships for MgO and Al_2O_3, Massachusetts Institute of Technology, Cambridge, June 13–16, 1983:

P. Angelini,* P. S. Sklad, J. Bentley, and C. J. McHargue, "Analytical Electron Microscopy of Ion-Implanted Al_2O_3"

J. Bentley, P. Angelini,* and P. F. Becher, "Characterization of Alumina Toughened with Yttria-Doped Zirconia by Analytical Electron Microscopy"

Heavy-Section Steel Technology Program Vessel Integrity Review Group Meeting, Oak Ridge, Tennessee, June 14, 1983:

W. R. Corwin, "HSST Materials Investigations"

Seminar, Joint Research Center, Petten, Netherlands, June 16, 1983:

M. L. Grossbeck* and E. E. Bloom, "In-Reactor Uniaxial Fracture Strain of 20%-Cold-Worked Type 316 Stainless Steel"

Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies, Snowbird, Utah, June 19–23, 1983:

L. L. Horton* and J. Bentley, "Swelling Behavior of a Simple Ferritic Alloy"

R. L. Klueh* and J. M. Vitek, "Tensile Propeties of Three Commercial Ferritic Steels After Low-Temperature Irradiation"

P. Patriarca, "Use of Ferritic Steels in Breeder Reactors Worldwide"

V. K. Sikka, "Development of a Modified 9 Cr-1 Mo Steel for Elevated-Temperature Service"

V. K. Sikka,* M. G. Cowgill, and B. W. Roberts, "Creep Properties of Modified 9 Cr-1 Mo Steel"

P. F. Tortorelli* and J. H. DeVan, "Corrosion of an Fe-12 Cr-1 MoVW Steel in Thermally Convective Lithium"

J. M. Vitek* and R. L. Klueh, "Microstructure of HFIR-Irradiated 12 Cr-1 MoVW Ferritic Steel"

F. W. Wiffen* and R. T. Santoro, "Control of Activation Levels to Simplify Waste Management of Fusion Reactor Ferritic Steel Components"

American Society of Mechanical Engineers Fourth National Congress on Pressure Vessels and Piping, Portland, Oregon, June 19–24, 1983:

R. W. Swindeman,* K. Farrell, and J. B. Conway, "Time-Dependent Fatigue Behavior of Type 304 Stainless Steel Containing Microvoids in the Starting Microstructure"

Seminar, Centre d'Études Nucléaires, Mol, Belgium, June 20, 1983:

M. L. Grossbeck* and E. E. Bloom, "In-Reactor Uniaxial Fracture Strain of 20%-Cold-Worked Type 316 Stainless Steel"

Gordon Research Conference on Physical Metallurgy, Plymouth, New Hampshire, June 20–24, 1983:

C. T. Liu, "Mechanical Properties of Ordered Intermetallic Alloys"

Workshop on Evaluation of Simulation Technique for Radiation Damage in the Bulk of Fusion First-Wall Materials, Swiss Federal Institute for Reactor Research, Interlaken, Switzerland, June 27–30, 1983:

M. L. Grossbeck, "Investigation of Fusion Reactor Candidate First-Wall Materials Using Mixed-Spectrum Fission Reactors"

Fusion Reactor Faculty Workshop, sponsored by Oak Ridge Associated Universities and U.S. Department of Energy, Oak Ridge, Tennessee, June 27–July 1, 1983:

J. L. Scott, "Materials"

Naval Tribology Workshop, Annapolis, Maryland, June 28–30, 1983:

J. A. Carpenter, Jr. (presented by M. B. Peterson), "Overview of the Tribology Project of the Department of Energy (DOE) Energy Conversion and Utilization Technologies (ECUT) Program"

NATO Advanced Study Institute on Surface Engineering, Les Arcs, France, July 3–16, 1983:

C. J. McHargue,* B. R. Appleton, and C. W. White, "Structure Property Relationships in Ion-Implanted Ceramics"

Seminar, Joint Research Center, Ispra, Italy, July 4, 1983:

M. L. Grossbeck* and E. E. Bloom, "In-Reactor Uniaxial Fracture Strain of 20%-Cold-Worked Type 316 Stainless Steel"

American Carbon Society Carbon Conference, San Diego, California, July 16, 1983:

C. R. Kennedy, "The Effect of Steam Oxidation on the Fracture Mechanics of Graphite"

C. R. Kennedy,* W. P. Eatherly, and D. Minderman, "A Comparison of the Characteristics of Graphites Irradiated at 600 and 900°C"

Symposium on Energy Removal and Particle Control in Toroidal Fusion Devices, Princeton Plasma Physics Laboratory, Princeton, New Jersey, July 26–29, 1983:

R. E. Clausing, F. Waelbroech, J. Winter,* P. Weinhold, L. Könen, and N. Noda, "Effects of Wall Conditioning on Plasma Parameters, Impurities and Hydrogen Recycling in TEXTOR"

16th Annual International Metallographic Society Technical Meeting, Calgary, Alberta, Canada, July 27–28, 1983:

R. J. Gray* and R. S. Crouse, "Metallographic Examination of a Broken 1/4-in.-ID Type 304L Stainless Steel Pipe in the Weld Area from a Chemical Dissolver Vessel"

R. J. Gray,* R. K. Holbert, and T. H. Thrasher, "Microstructural Analysis of Series 300 Stainless Steel Welds and Tensile Specimens"

J. R. Keiser* and A. R. Olsen, "Corrosion Studies in Coal Liquefaction Plants"

P. F. Tortorelli* and J. H. DeVan, "Effects of a Flowing Lithium Environment on the Surface Morphology and Composition of Austenitic Stainless Steel"

New Rings Workshop, Stanford Synchrotron Radiation Laboratory, Stanford, California, July 27–29, 1983:

G. E. Ice, "Near Threshold Electron Spectroscopy"

41st Annual Electron Microscopy Society of America Meeting, Phoenix, Arizona, August 6–12, 1983:

P. Angelini,* J. Bentley, C. B. Finch, and P. S. Sklad, "Microstructure of TiB_2 Liquid Phase Sintered with Ni_3Al"

P. Angelini, G. L. Lehman,* and J. Brynestad, "Microstructure of Highly Reactive Submicrometer TiB_2 Powders"

J. Bentley,* L. D. Stephenson, R. B. Benson, Jr., and P. A. Parrish, "In Situ Annealing of Aluminum Ion Implated with Molybdenum"

D. N. Braski,* P. D. Godell, J. V. Cathcart, and R. H. Kane, "The Oxidation of Inconel Alloy MA754 at Low Oxidation Potential"

G. C. Hadjipanayis and L. L. Horton,* "Lorentz Electron Microscopy of Rare-Earth Permanent Magnets"

J. A. Horton,* C. C. Koch, and C. T. Liu, "Segregation and Domain Structure in Rapidly Solidified Ni_3Al"

L. L. Horton* and K. Farrell, "Comparison of Damage Microstructures in Neutron-Irradiated Vanadium and Iron"

E. A. Kenik* and E. H. Lee, "Radiation Damage and Phase Instability in Irradiated Stainless Steel"

R. J. Lauf, "Irradiation Behavior of Pyrolytic Silicon Carbide"

P. J. Maziasz, "Identification of Preferential Polishing Effects Using Broad Probe AEM"

P. J. Maziasz* and G. R. Odette, "Wide Area-Beam Averaged AEM of Precipitate Particles Extracted on Replicas from Type 316 Stainless Steel"

P. S. Sklad,* P. Angelini, M. B. Lewis, J. T. Houston, and C. J. McHargue, "Analytical Electron Microscopy of TiB_2 Implanted with 1 MeV Nickel"

L. D. Stephenson,* J. Bently, R. B. Benson, Jr., and P. A. Parrish, "Analytical Electron Microscopy of Aluminum Ion Implanted with Molybdenum"

Review of Progress in Quantitative NDE, University of of California, Santa Cruz, August 7–12, 1983:

W. A. Simpson, Jr.,* and R. W. McClung, "Ultrasonic Characterization of Advanced Composite Flywheels"

Symposium on Refractory Alloy Technology for Space Nuclear Power Applications, Technical Information Center, Oak Ridge, Tennessee, August 10–11, 1983:

F. W. Wiffen, "Effects of Irradiation on Properties of Refractory Alloys with Emphasis on Space Power Reactor Applications"

Fifth International Conference on Liquid and Amorphous Metals, University of California, Los Angeles, August 15–23, 1983:

D. M. Kroeger,* C. C. Koch, G. C. McKamey, and J. O.Scarbrougn, "The Effect of Chemical Short Range Ordering on Crystallization of Zr-Ni Glasses"

D. M. Kroeger,* C. C. Koch, J. O. Scarbrough, and G. C. McKamey, "Stability and Electronic Properties of Zr-Ni Glasses"

Seventh International Conference on High Voltage Electron Microscopy, Berkeley, California, August 16–19, 1983:

E. A. Kenik, "Dynamic Recording System for HVEM In Situ Studies"

E. A. Kenik,* R. Crooks, and E. A. Starke, "In Situ Deformation and Fracture Studies on Precipitation-Hardened Aluminum Alloys"

18th Intersociety Energy Conversion Engineering Conference, Orlando, Florida, August 21–26, 1983:

T. S. Lundy, "Building Envelope Research Utilization"

Meeting of L. H. Roddis, Jr., Chairman, Energy Research Advisory Board to the U. S. Department of Energy, with the ORNL Fusion Energy Division, Y-12 Plant, Oak Ridge, Tennessee, August 23, 1983:

J. L. Scott, "Bulk Materials"

Seminar, Iowa State University-Ames Laboratory, Ames, August 30, 1983:

A. DasGupta, "Metallic Glasses and Rapidly Quenched Crystalline Alloys – Some Studies"

American Society for Nondestructive Testing Section Meeting, Nashville, Tennessee, September 12, 1983:

J. H. Smith, "Basic Introduction to Nondestructive Testing"

Physical and Chemical Energy Storage Contractors' Annual Review Meeting, Arlington, Virginia, September 12–14, 1983:

L. A. Harris (presented by Mitchell Olszewski), "Structural Properties of Composite TES Media"

U.S. Department of Energy Third National Conference on Synchrotron Radiation Instrumentation, Brookhaven National Laboratory, Upton, N.Y., September 12–14, 1983:

G. E. Ice* and C. J. Sparks, Jr., "Focusing Optics for a Synchrotron X-Radiation Microprobe"

Third Topical Meeting on Fusion Reactor Materials, Albuquerque, New Mexico, September 19–22, 1983:

D. N Braski, "Microstructure and Bend Ductility of an $(Fe,Ni)_3V$ Alloy Irradiated in HFIR"

D. N. Braski* and P. J. Maziasz, "Tensile Properties of Unirradiated PCA from Room Temperature to 70°C"

R. E. Clausing* and L. Heatherly, "Surface Composition Changes of Inconel 625 During RG and ECR Glow Discharge Cleaning of TEXTOR at 300°C"

W. A. Coghlan* and L. K. Mansur, "Critical Radius for Cavities Containing a Van der Waals Gas"

W. R. Corwin,* R. L. Klueh, and J. M. Vitek, "Effect of Specimen Size and Nickel Content on the Impact Properties of 12 Cr-1 MoVW Ferritic Steel"

M. L. Grossbeck* and K. C. Liu, "Fatigue Behavior at 650°C of 20%-Cold-Worked Type 316 Stainless Steel Irradiated at 550°C in the HFIR"

M. L. Grossbeck* and K. C. Liu, "Fatigue Performance of HFIR-Irradiated Nimonic PE-16 at 430°C"

A. Hishinuma, N. H. Packan,* E. H. Lee, and L. K. Mansur, "Effects of Pulsed and/or Dual Ion Irradiation on Microstructural Evolution in Ti and Si Modified Austenitic Alloys"

L. L. Horton* and K. Farrell, "A TEM Study of Neutron-Irradiated Vanadium"

L. L. Horton* and K. Farrell, "The Temperature Dependence of the Damage Microstructures in Neutron-Irradiated Vanadium"

R. L. Klueh* and M. L. Grossbeck, "A Comparison of the Irradiated Tensile Properties of a High-Manganese Austenitic Steel and Type 316 Stainless Steel"

E. H. Lee,* L. K. Mansur, and A. F. Rowcliffe, "The Effect of Phosphorus on the Swelling and Precipitation Behavior of Austenitic Stainless Steels During Irradiation"

K. C. Liu and C. M. Loring, Jr. (presented by R. L. Klueh), "Low-Cycle Fatigue Behavior of Oxygen-Free High-Conductivity Copper at 300°C in High Vacuum"

R. F. Mattas,* F. A. Garner, M. L. Grossbeck, P. J. Maziasz, G. R. Odette, and R. Stoller, "The Impact of Swelling on Fusion Reactor First Wall Lifetime"

P. J. Maziasz, "Anticipating Fusion Swelling Resistance for Austenitic Stainless Steels Based on Fission Reactor Data"

P. J. Maziasz, "Comparison of Dislocation and Precipitation Evolution for Type 316 Stainless Steel Irradiated in EBR-II and HFIR"

P. J. Maziasz, "Comparison of Swelling and Cavity Microstructural Development for Type 316 Stainless Steel Irradiated in EBR-II and HFIR"

P. J. Maziasz, "Swelling and Swelling Resistance Possibilities of Austenitic Stainless Steels in Fusion Reactors"

P. J. Maziasz* and D. N. Braski, "Alloy Development Summary for Path A Prime Candidate Alloy: Grain Boundary Microstructural Development and Stability Under HFIR Irradiation"

P. J. Maziasz* and D. N. Braski, "Alloy Development Summary for Path A Prime Candidate Alloy: Swelling and Microstructural Development Under HFIR Irradiation"

P. J. Maziasz,* and D. N. Braski, "Improved Swelling Resistance for PCA Austenitic Stainless Steel Under HFIR Irradiation Through Microstructural Control"

K. Miyahara,* N. H. Packan, and N. Igata, "The Effect of Pulsed Irradiation on Void Swelling of a Pure Austenitic Alloy"

N. H. Packan, "Temperature Aspects of Pulsed Ion Bombardment in an Austenitic Alloy"

A. F. Rowcliffe* and M. L. Grossbeck, "Radiation Effects in Austenitic Steels"

A. F. Rowcliffe* and M. L. Grossbeck, "The Response of Austenitic Steels to Radiation Damage"

E. P. Simonen,* N. M. Ghoniem, and N. H. Packan, "Pulsed Flux Effects on Radiation Damage"

P. S. Sklad* and H. Schroeder, "The Effect of Implanted Helium on the Microstructure and Creep Properties of Ordered $(Fe_{0.49}Ni_{0.51})_3V$ Alloys"

P. F. Tortorelli* and J. H. DeVan, "Mass Transfer Behavior of a Modified Austenitic Stainless Steel in Lithium"

P. F. Tortorelli* and J. H. Devan, "Surface Analysis of Ferrous Alloys Exposed to Static Pb-17 at. % Li"

J. M. Vitek* and R. L. Klueh, "Microstructure of 9 Cr-1 MoVNb Steel Irradiated to 40 dpa at Elevated Temperatures in HFIR"

F. W. Wiffen, "FEDC Design of Experimental Fusion Reactors"

F. W. Wiffen,* T. C. Reuther, and R. E. Gold, "Summary Report on the DOE-OFE Workshop 'Copper and Copper Alloys for Fusion Reactor Applications'"

Meeting of American Society for Nondestructive Testing, Chattanooga Section, Chattanooga, Tennessee, September 20, 1983:

J. H. Smith, "Ultrasonic Inspection of Dissimilar-Metal Weld Joints"

American Society for Testing and Materials Symposium on the Use of Nonstandard Subsized Specimens for Irradiation Testing, Albuquerque, New Mexico, September 23, 1983:

W. R. Corwin* and A. M. Hougland, "Effect of Specimen Size and Material Condition on the Charpy Impact Properties of 9 Cr-1 Mo Steel"

R. L. Klueh* and D. N. Braski, "Disk-Bend Ductility Tests for Irradiated Materials"

K. C. Liu and M. L. Grossbeck,* "Use of Subsized Fatigue Specimens for Reactor Irradiation Testing"

Advanced Reactor Sessions of the ASME-AIEE Joint Power Generator Conference, Indianapolis, Indiana, September 25-29, 1983:

J. A. Horak, "Long-Term Mechanical Properties of Materials for LMFBR Components"

Ninth International Vacuum Congress and Fifth International Conference on Solid Surfaces, Madrid, Spain, September 26-October 1, 1983:

F. G. Waelbroeck,* J. Winter, P. Wienhold, L. Könen, T. Banno, L. Groubusch, E. Rota, K. G. Tschersich, and R. E. Clausing, "First Wall Conditioning of TEXTOR"

American Society for Metals 1983 Metals Congress-The Metallurgical Society of AIME Fall Meeting, Philadelphia, Pennsylvania, October 1-6, 1983:

J. E. Cunningham, "Fusion Reactor Materials"

J. A. Horton* and C. C. Koch, "Microstructural Characterization of Rapidly Solidified and Welded Ni_3Al"

Y. L. Hotsur and V. K. Sikka,* "Mechanical Properties and Microstructure of an Electroslag"

R. L. Klueh* and R. W. Swindeman, "Creep Behavior of a Modified 2 1/4 Cr-1 Mo Steel for Pressure Vessel Applications"

J. H. Schneibel,* G. F. Petersen, and M. H. Yoo, "Grain Boundary Sliding and Segregation"

J. H. Schneibel* and H. Trinkaus, "Cavitation in the Diffusional Creep Regime"

R. W Swindeman* and C. W. Houck, "Comparison of Metallographic Techniques for the Examination of Creep-Damaged Type 304 Stainless Steel"

P. F. Tortorelli,* J. H. DeVan, and J. R. Keiser, "Oxidation of Fe-Ni-Cr Alloys by Nitrate and Nitrate-Nitrite Salts"

C. L. White* and R. A. Padgett, Jr., "Application of Unusual Metallographic Techniques to the Study of Grain Boundary Cavitation in Nickel + 1% Sb"

M. H. Yoo,* C. L. White, and H. Trinkaus, "Interfacial Segregation and Fracture"

18th International Conference on Thermal Conductivity, Rapid City, South Dakota, October 2–6, 1983:

G. L. Copeland,* D. L. McElroy, and H. A. Fine, "Insulations with Low Thermal Conductivity"

R. S. Graves,* D. W. Yarbrough, and D. L. McElroy, "Apparent Thermal Conductivity Measurements by an Unguarded Technique"

J. P. Moore, F. J. Weaver, R. S. Graves, and D. L. McElroy,* "The Thermal Conductivity and Expansion Enhancement Associated with Formation of the Superionic State in $SrCl_2$"

J. P. Moore, F. J. Weaver, and D. L. McElroy,* "The Thermal Conductivities of $SrCl_2$ and SrF_2 from 85 to 400 K"

R. K. Williams,* F. J. Weaver, and R. S. Graves, "Transport Properties of Polycrystalline Ni_3Al"

Department of Energy Committee on Synchrotron Radiation Facilities Meeting, Albuquerque, New Mexico, October 8–10, 1983:

C. J. Sparks, Jr.,* and G. E. Ice, "Requirements on Advanced Storage Rings for an X-Ray Fluorscence Microprobe"

International Atomic Energy Agency International Working Group on Fast Reactors Specialists' Meeting on Mechanical Properties of Structural Materials Including Environmental Effects, Chester, England, October 10–14, 1983:

J. A. Horak,* V. K. Sikka, and D. T. Raske, "Review of Mechanical Properties and Microstructures of Types 304 and 316 Stainless Steel After Long-Term Aging"

Seminar, University of Pennsylvania, Philadelphia, October 11, 1983:

C. T. Liu, "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

Seminar, Tokyo Institute of Technology, Tokyo, Japan, October 13–14, 1983:

W. J. Lackey, "Chemical Vapor Deposition of Ceramic Coatings"

International Symposium on Ceramic Components for Engine, Hakone, Japan, October 17–21, 1983:

W. J. Lackey,* D. P. Stinton, G. A. Cerney, L. L. Fehrenbacher, and A. C. Schaffhauser, "Ceramic Coatings for Heat Engine Materials—Status and Future Needs"

C. S. Yust, "Wear Coefficients and Wear of Sliding Ceramics"

C. S. Yust* and F. J. Carignan, "Damage Processes in Sliding Partially Stabilized Zirconia Pairs"

Department of Energy Materials Directors' Meeting, Los Alamos, New Mexico, October 19–20, 1983:

J. E. Cunningham, "Solidification and Phase Stability in Austenitic Stainless Steels"

11th Water Reactor Safety Research Information Meeting, National Bureau of Standards, Gaithersburg, Maryland, October 24–28, 1983:

C. V. Dodd, "Improved Multifrequency Eddy-Current Testing of Steam Generator Tubing"

Meeting of the Oak Ridge Chapter of the American Vacuum Society, Oak Ridge, Tennessee, October 27, 1983:

G. E. Ice, "New Surface Research Opportunities with Synchrotron Radiation"

American Ceramic Society Fall Meeting, Columbus, Ohio, October 30–November 2, 1983:

P. F. Becher and G. C. Wei,* "Toughening Behavior in SiC Whisker Reinforced Alumnia"

C. B. Finch,* P. Angelini, P. F. Becher, and J. Brynestad, "Effect of Oxygen and Carbon on the Densification and Grain Size of Hot-Pressed Submicrometer TiB_2 Powders"

G. C. Wei,* P. F. Becher, and R. L. Beatty, "Silicon Carbide Whisker Reinforced Aluminum Oxide Composite"

American Institute of Chemical Engineers Diamond Jubilee Meeting, Washington, D.C., October 31–November 4, 1983:

J. R. Keiser,* A. R. Olsen, and R. R. Judkins, "Corrosion of Alloys in Direct Coal Liquefaction Systems"

Meeting of American Society for Metals Hudson Valley Chapter, Nyack, New Jersey, November 1, 1983:

G. M. Slaughter, "Brazing and Soldering Technology—Past, Present, and Future"

Fourth International Brazing and Soldering Conference, British Association for Brazing and Soldering, London, England, November 1–3, 1983:

A. J. Moorhead and P. F. Becher,* "Wetting and Bonding Behavior in Some Metal-Alumina Systems"

Symposium on Automated Test Methods for Fracture and Fatigue Crack Growth, Pittsburgh, Pennsylvania, November 7–8, 1983:

J. J. McGowan* and J. L. Keating, "A Microprocessor-Based System for Determining Near-Threshold Fatigue Crack Growth Rates"

Department of Energy Contractors' Meeting on Heterogeneous Catalysis, National Bureau of Standards, Gaithersburg, Maryland, November 7–9, 1983:

P. J. Reucroft,* R. J. DeAngelis, and J. Bentley, "Structural Characterization of Dispersed Metal Catalysts"

21st Automotive Technology Development Contract Coordinators' Meeting, Dearborn, Michigan, November 14–17, 1983:

P. F. Becher* and G. C. Wei, "Transformation Toughened and Whisker Reinforced Ceramics"

A. J. Moorhead,* T. N. Tiegs, and R. J. Lauf, "Dispersed Metal-Toughened Ceramics and Ceramic Brazing"

Annual Materials Research Society Meeting, Boston Massachusetts, November 14–18, 1983:

P. Angelini,* P. F. Becher, J. Bentley, C. B. Finch, and P. S. Sklad, "Processing and Microstructural Characterization of TiB_2 Liquid Phase Sintered with Ni and Ni_3Al"

J. Bentley,* L. D. Stephenson, R. B. Benson, Jr., R. A. Parrish, and J. K. Hirvonen, "Second Phase Formation in Aluminum Annealed After Ion Implantation with Molybdenum"

G. W. Clark, "Eutectic Soldification of the Systems Al_2O_3-TiB_2, Al_2O_3-ZrB_2, Y_2O_3-TiB_2, and ZrO_2-ZrB_2"

G. C. Farlow,* C. W. White, C. J. McHargue, and B. R. Apppleton, "Behavior of Implanted Alpha-Al_2O_3 in an Oxidizing Annealing Environment"

J. I. Federer and R. J. Lauf,* "Crystallization Behavior of Hygas Ash"

R. J. Lauf, "Characterization of the Mineralogy and Michochemistry of Fly Ash"

M. B. Lewis* and C. J. McHargue, "High Energy Ion Beam Mixing in Al_2O_3"

C. J. McHargue,* C. W. White, B. R. Appleton, G. C. Farlow, and J. M. Williams, "Ion Beam Modification of Ceramics"

P. S. Sklad,* P. Angelini, M. B. Lewis, and C. J. McHargue, "Microstructural Development of TiB_2 Ion Implanted with 1 MeV Nickel"

J. A. Spitznagel,* B. O. Hall, N. J. Doyle, R. Jayrom, R. W. Wallace, J. R. Townsend, and M. Miller, "Ion Implantation and Ion Beam Processing of Materials"

D. P. Stinton,* E. W. McDaniel, and H. O. Weeren, "Partitioning of Cesium in Phases Produced by Grouted Waste Injection"

Symposium on An On-Line Materials Property Data Base, American Society of Mechanical Engineers, Boston, Massachusetts, November 15, 1983:

J. J. McGowan, "Use of An On-Line Data Base in Pressure Vessel Design"

Seminar, Henry Kromb School of Mines, Colulmbia University, New York, November 16, 1983:

J. S. Faulkner, "Alloy Theory and Applications"

Symposium on High-Temperature Materials for Coal Conversion and Utilization, Mol, Belgium, sponsored by the Laboratory of the Studiecentrum voor Kernenergie/Centre D'étude de L'énergie Nucléaire, November 17, 1983:

R. A. Bradley,* R. R. Judkins, and J. P. Hammond, "Materials for Coal Conversion Systems"

Seminar, University of Connecticut, Storrs, November 30, 1983:

S. A. David, "Soldification Behavior, Microstructure, and Modification of Austenitic Stainless Steel Weld Metal"

Japan-U.S. Workshop on Fusion Reactor Materials, Tsukuba, Japan, December 5–7, 1983:

L. K. Mansur,* W. A. Coghlan, K. Farrell, L. L. Horton, E. H. Lee, M. B. Lewis, and N. H. Packan, "Fusion-Relevant Basic Radiation Effects—Theory and Experiment"

A. F. Rowcliffe,* M. L. Grossbeck, and P. J. Maziasz, "The Response of Austenitic Steels to Radiation Damage"

Seminar, Solid State Physics Department, Universidad Nacional Autónoma de México, Mexico City, December 6, 1983:

J. H. Schneibel, "Creep Cavitation in Ni–20% Cr and Its Inhibition by Small Additions of Zirconium"

Tenth Institute of Electrical and Electronics Engineers Symposium on Fusion Reactor Technology, Philadelphia, Pennsylvania, December 6, 1983:

E. E. Bloom, T. C. Reuther, and J. L. Scott,* "Candidate First-Wall Materials for Fusion Reactors"

Seminar, Columbia University, New York, December 7, 1983:

C. T. Liu, "Design of Ductile Ordered Alloys for High-Temperature Structural Uses"

Seminar, Hokkaido University, Sapporo, Japan, December 12, 1983:

L. K. Mansur, "Radiation Effects in Structural Materials"

Electric Power Research Institute Fusion Program Review, Palo Alto, California, December 14–15, 1983:

R. L. Klueh* and J. M. Vitek, "Elevated-Temperature Tensile Properties of Irradiated 2 1/4 Cr-1 Mo Steel"

Seminar, Allied Corporation, Morristown, New Jersey, December 15, 1983:

A. Bleier, "Ceramics Processing and Its Relation to Colloid Science"

Seminar, Defense Metallurgical Research Laboratory, Hyderbad, India, December 31, 1983–January 1, 1984:

J. A. Carpenter, Jr., "Overview of the Materials and Tribology Projects of the United States Department of Energy (DOE) Energy Conversion and Utilization Technologies (ECUT) Program"

C. T. Liu (presented by J. A. Carpenter, Jr.), "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

Seminar, Indian Institute of Technology, Madras, India, January 5 and 7, 1984:

J. A. Carpenter, Jr., "Overview of the Materials and Tribology Projects of the United States Department of Energy (DOE) Energy Conversion and Utilization Technologies (ECUT) Program"

C. T. Liu (presented by J. A. Carpenter, Jr.), "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

Meeting of American Society for Metals Cleveland Chapter, Cleveland, Ohio, January 9, 1984:

G. M. Slaughter, "Materials R&D for Energy Applications"

Seminar, Indian Institute of Sciences, Bangalore, India, January 9, 1984:

C. T. Liu (presented by J. A. Carpenter, Jr.), "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

Seminar, Carnegie-Mellon University, Pittsburgh, Pennsylvania, January 12, 1984:

S. A. David, "Soldification Behavior, Microstructure, and Modification of Austenitic Stainless Steel Weld Metal"

Seminar, Sandia National Laboratories, Albuquerque, New Mexico, January 12, 1984:

C. J. McHargue, "Ion Implantation and Ceramics"

Eighth American Ceramic Society Annual Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, Florida, January 15–20, 1984:

A. J. Caputo* and W. J. Lackey, "Fabrication of Fiber-Reinforced Ceramic Composites"

D. P. Stinton,* W. J. Lackey, and R. J. Lauf. "Fabrication of Ceramic-Ceramic Composites by Chemical Vapor Deposition"

C. S. Yust, "Wear Coefficients of Sliding Ceramics".

Seminar, Banares Hindu University, Varanasi, India, January 16, 1984:

C. T. Liu (presented by J. A. Carpenter, Jr.), "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

General Physics Seminar, Bell Laboratories, Murray Hill, New Jersey, January 17, 1984:

G. M. Stocks, "Fermi Surface Driven Concentration Waves in Random Alloys"

Meeting of Technical Society of Knoxville, Knoxville, Tennessee, January 20, 1984:

D. R. Johnson, "Ceramic Technology for Advanced Automotive Engines"

Seminar, India Chapter of American Society for Metals, Bombay, India, January 24, 1984:

J. A. Carpenter, Jr., "Overview of the Materials and Tribology Projects of the United States Department of Energy (DOE) Energy Conversion and Utilization Technologies (ECUT) Program"

C. T. Liu (presented by J. A. Carpenter, Jr.), "Recent Development of Ductile Ordered Intermetallic Alloys for High Temperature Use"

Seminar, University of Tennessee, Knoxville, January 24, 1984:

A. Bleier, "Application of Colloid Chemistry to Ceramics"

Naval Research Laboratory Meeting, Washington, D.C., February 9, 1984:

P. F. Becher, "Toughening Behavior in Ceramic Composites"

Meeting of Oak Ridge Chapter of American Society for Metals, Oak Ridge, Tennessee, February 9, 1984:

R. J. Gray, "There Are No Fortune Cookies in China"

Energy Sources Technology Conference and Exhibition, New Orleans, Louisiana, February 12–16, 1984:

A. R. Olsen,* J. R. Keiser, and R. R. Judkins, "Materials for Coal Liquefaction Systems"

11th Annual Welding and Testing Technology Exhibition and Conference, Knoxville, Tennessee, February 21–24, 1984:

R. S. Crouse, "Metallography of Highly Radioactive Materials"

R. J. Gray, "Metallography Can Be Colorful"

J. R. Keiser* and B. C. Leslie, "Metallography for Coal Liquefaction Pilot Plants"

Electric Power Research Institute Conference on Solutions to Problems with Dissimilar-Metal Weldments in Fossil-Fired Power Plants, New Orleans, Louisiana, February 23–24, 1984:

G. M. Goodwin, "An Overview of the MPC Dissimilar-Metal Weld Program"

American Institute of Mining, Metallurgical, and Petroleum Engineers Annual Meeting, Los Angeles, California, February 26–March 2, 1984:

D. N. Braski* and C. T. Liu, "The Development of $(Fe,Ni)_3V$ Long-Range-Ordered Alloys for a Fusion Reactor First Wall"

C. R. Brinkman* and V. K. Sikka, "Optimized Specifications for Types 304 and 316 Stainless Steel in Long-Term High-Temperature Service Applications"

Y. T. Chou* and A. DasGupta, "Flux Pinning by Grain Boundaries in Type II Superconductors"

W. A. Coghlan,* B. A. Chin, and L. K. Mansur, "Microstructural Dependence of the Ratio of Irradiation Creep to Swelling"

R. L. Klueh* and E. E. Bloom, "Alloy Development for Fast Induced Radioactivity Decay for Fusion Reactor Applications"

C. T. Liu* and C. L. White, "Effect of Alloy Stoichiometry on Ductility and Fracture Behavior of Boron-Doped Ni_3Al"

P. J. Maziasz, "Strategies and Results Underlying the Development of Advanced Austenitic Stainless Steels for Fusion"

J. H. Schneibel* and C. L. White, "The Effect of Small Alloying Additions on the Creep Deformation and Fracture of an Austenitic Stainless Steel"

V. K. Sikka, "Modified 9 Cr-1 Mo Steel—An Improved Alloy for Steam Generator Application"

P. F. Tortorelli* and J. H. DeVan, "Liquid Metal Compatibility Considerations in Alloy Development"

H. Trinkaus* and M. H. Yoo, "Intergranular Cavity Nucleation Under Time-Dependent Stress Concentrations"

C. L. White* and M. H. Yoo, "On the Temperature and Composition Dependence of Interfacial Energy"

R. O. Williams, "Calculation of Coherent Phase Equilibria"

Materials Science Colloquium, University of Virginia, Charlottesville, February 27, 1984:

L. K. Mansur, "Mechanisms of Radiation Effects in Metals and Alloys"

Spring Meeting of Materials Research Society, Albuquerque, New Mexico, February 27–29, 1984:

R. E. Riman, D. M. Haaland, C. J. Northrup, Jr., H. K. Bowen, and A. Bleier,* "FTIR Study of Alkoxide Precusors to $SrTiO_3$"

Meeting of Rocky Mountain Chapter of American Society for Metals, Colorado School of Mines, Golden, Colorado, March 1, 1984:

R. W. Swindeman, "Developments in Microalloyed Ferritic Steels for High-Temperature Pressure Vessel Applications"

Department of Energy Meeting on Submicron Ceramic Powders, Albuquerque, New Mexico, March 1–2, 1984:

A. Bleier, "Analytical Problems of Submicron Nitride and Carbide Powders"

Seminar, Rensselaer Polytechnic Institute, Troy, New York, March 6, 1984:

S. A. David, "Welding and Weldability of Thorium-Doped Iridium Alloys Used for Space Power Systems"

Meeting, Waste Management/84, University of Arizona, Tucson, March 11–15, 1984:

J. C. Griess, "Considerations in Estimating Corrosion of Metallic Containers in Nuclear Waste Repositories"

Seminar, Department of Materials Science, Stanford University, Stanford, California, March 15, 1984:

J. Bentley, "A Critical Evaluation of Analytical Electron Microscopy in Materials Science"

Meeting of Major Materials Facilities Committee, National Research Council, Washington, D.C., March 17–20, 1984:

C. J. Sparks, Jr., "Materials Science with Synchrotron Radiation. The Case for a Superprobe"

C. J. Sparks, Jr., "X-Ray Microprobe Characterization of Materials: The Case for Undulators on Advanced Storage Rings"

Meeting of the American Physical Society, Detroit, Michigan, March 26–30, 1984:

W. H. Butler, "Theory of Electronic Transport in Random Alloys: Korringa-Kohn-Rostoker-Coherent-Potential Approximation"

A. P. Maclin,* G. M. Stocks, and W. M. Temmerman, "Band Structure Calculations of Aluminides"

D. M. Nicholson* and J. S. Faulkner, "Non-Muffin-Tin Effects in Transition Metals"

Second Workshop on Examination of Radioactive Materials by Electron Beam Methods, Savannah River Laboratory, Aiken, South Carolina, March 29–30, 1984:

D. N. Braski* and J. R. Gibson, "Modification of an SEM for Examination of Radioactive Materials"

Seminar, University of Missouri, Rolla, March 30, 1984:

N. H. Packan, "Pulsed Dual-Ion Irradiations of Stainless Steels,"

Second International Conference on Creep and Fracture of Engineering Materials and Structures, Swansea, England, April 1–6, 1984:

C. L. White,* J. H. Schneibel, and M. H. Yoo, "Sulfur and Antimony Segregation to Creep Cavity Surfaces in Ni and an FCC Fe-Ni-Cr Alloy"

International Topical Conference on Kinetics of Aggregation and Gelation, University of Georgia, Athens, April 2–4, 1984:

M. K. Miller,* S. S. Brenner, P. P. Camus, and W. A. Soffa, "The Atom Probe—A Direct Technique for Kinetic Measurements"

Fourth International Conference on High-Temperature and Energy-Related Materials, Los Alamos, New Mexico, April 2–6, 1984:

D. W. Yarbrough,* T. W. Tong, and D. L. McElroy, "Use of Fine Powders for High Thermal Resistance"

North Atlantic Treaty Organization Conference on Ceramic Coatings for Advanced Heat Engines, Aqua Fredda de Maratea, Italy, April 2–6, 1984:

A. C. Schaffhauser, "Department of Energy Program on Ceramic Technology for Advanced Heat Engines"

Seminar, Department of Metallurgical, Chemical, and Polymer Engineering, University of Tennessee, Knoxville, April 3, 1984:

R. W. McClung, "An Overview of Nondestructive Testing"

Inorganic Chemistry Colloquium, University of Nottingham, Nottingham, England, April 5, 1984:

P. F. Tortorelli, "Liquid Metal Corrosion Studies"

American Society for Metals Meeting of Lehigh Valley Chapter, Bethlehem, Pennsylvania, April 6, 1984:

G. M. Slaughter, "Brazing and Soldering Technology—Past, Present, and Future"

Symposium, Rocky Mountain Chapter, American Society for Metals, Colorado School of Mines, Golden, Colorado, April 6, 1984:

R. J. Gray, "A Look at Metallography of Yesterday, Today, and Tomorrow"

65th Annual American Welding Society Meeting, Dallas, Texas, April 8–13, 1984:

R. K. Holbert, Jr.,* S. A. David, and G. M. Goodwin, "Hot Cracking Susceptibility Test for Thin Austenitic Stainless Steel Sheet"

J. M. Vitek* and S. A. David, "The Sigma Phase Transformation in Type 308 Austenitic Stainless Steel Welds"

Oak Ridge National Laboratory Fusion Energy Division Annual Information Meeting, Oak Ridge, Tennessee, April 9–10, 1984:

J. L. Scott,* E. E. Bloom, D. N. Braski, M. L. Grossbeck, R. L. Klueh, P. J. Maziasz, A. F. Rowcliffe, P. F. Tortorelli, J. M. Vitek, J. A. Conlin, Jr., I. T. Dudley, E. M. Lees, C. D. West, and R. A. Lillie, "Fusion Materials Program"

ORNL-TMS-AIME Conference on High-Temperature Alloys: Theory and Design, Bethesda, Maryland, April 9–11, 1984:

W. H. Butler, "First Principles Design of Transport Properties of High-Temperature Alloys"

W. H. Butler, "Resistivity of Alloys"

A. DasGupta* and C. T. Liu, "Phase Formation and Stability in the Pseudobinary Ni_3V-Ni_3Al Alloy System"

J. A. Horton,* H. Inouye, C. T. Liu, and C. C. Koch, "Alloying Effects and Microstructure of Iron Aluminides"

C. T. Liu, "Design of Ordered Intermetallic Alloys for High-Temperature Structural Use"

A. P. Maclin,* G. M. Stocks, and W. M. Temmerman, "Band-Structure Calculations of Aluminides"

D. M. Nicholson* and A. Chowdhary, "Electronic Structure of Liquid Metal Alloys"

G. M. Stocks, "Fermi Surface Driven Concentration Waves in Random Alloys"

Third International Conference on Liquid Metal Engineering and Technology in Energy Production, Oxford, England, April 9–13, 1984:

J. H. DeVan* and C. Bagnall, "A Perspective of the Corrosive Behavior of Lithium and Sodium"

P. F. Tortorelli* and J. H. DeVan, "Mass Transfer Kinetics in Lithium–Stainless Steel Systems"

Seminar, Massachusetts Institute of Technology, Cambridge, April 12, 1984:

P. J. Maziasz, "Influence of Precipitate Evolution on Property Changes in Austenitic Stainless Steels for Fusion"

Seminar. Naval Surface Weapons Center, White Oak, Silver Springs, Maryland, April 12, 1984:

C. T. Liu, "Development of New Structural Materials Based on Ordered Intermetallic Alloys"

Seminar, Culham Laboratory, Culham, England, April 13, 1984:

P. F. Tortorelli, "Liquid Metal Corrosion Considerations in Fusion Blanket Design"

Seminar, North Carolina State University, Raleigh, April 18, 1984:

M. H. Yoo, "High-Temperature Deformation and Fracture"

Meeting, Philadelphia Chapter of the American Society for Metals, Philadelphia, Pennsylvania, April 19, 1984:

R. J. Gray, "Modern Metallography—New and Unusual Methods to Analyze Microstructures"

American Society for Metals Conference on Materials for Energy Systems, Washington, D.C., April 29–May 2, 1984:

E. E. Bloom* and D. L. Smith, "Fusion Reactor Blanket Structural Materials"

86th Annual American Ceramic Society Meeting, Pittsburgh, Pennsylvania, April 29–May 3, 1984:

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W. J. Lackey,* P. Angelini, A. J. Caputo, C. E. DeVore, J. C. McLaughlin, D. P. Stinton, and R. E. Hutchens. "Improved Rate Controlled Technique for Drying and Calcining"

C. J. McHargue, B. R. Appleton, J. M. Williams, M. B. Lewis, and C. S. Yust (presented by G. C. Farlow), "Inert Gas Implantation Effects in Al_2O_3"

R. E. Riman, A. Bleier,* and H. E. Bomen, "Solution Environment Effects on the Synthesis of $SrTiO_3$ Powder"

P. S. Sklad, C. J. McHargue, and J. M. Williams (presented by C. S. Yust), "Microstructural Development in SiC Ion Implanted with Chromium"

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G. C. Wei* and P. F. Becher, "Improvements in Mechanical Properties in SiC by the Addition of TiC Particles"

G. C. Wei* and P. F. Becher, "Processing and Properties of SiC-TiC Composites"

1984 Pacific Northwest Metals and Minerals Conference, Portland, Oregon, April 30–May 2, 1984:

S. A. David, "Welding and Weldability of Ductile Iron Nickel Aluminides"

1984 Institute of Engineering Faculty, American Consulting Engineers Council, Ohio State University, Columbus, April 30–May 3, 1984:

T. S. Lundy, "The National Program Concept"

Casting Congress, American Foundrymen Society, St. Louis, Missouri, April 30–May 4, 1984:

V. K. Sikka* and A. Mitchell, "Steel Castings by the Electroslag Casting Technique"

American Society for Metals Conference on Materials for Future Energy Systems, Washington, D.C., May 1–3, 1984:

E. E. Hoffman* and R. H. Cooper, Jr., "Fuel Systems and Structural Alloys for Space Nuclear Reactor Systems"

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J. R. Weir, Jr., "Role of Materials: Priorities"

Fourth Annual Symposium of the Tennessee Valley Chapter of the American Vacuum Society, Knoxville, Tennessee, May 1–3, 1984:

D. N. Braski,* P. D. Goodell, J. V. Cathcart, and R. H. Kane, "The Oxidation of Inconel Alloy MA754 at Low Oxidation Potential"

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Ninth Conference on Chemical Vapor Deposition, Cincinnati, Ohio, May 6, 1984:

A. J. Caputo,* W. J. Lackey, and I. G. Wright, "Chemical Vapor Deposition of Erosion Resistant TiB_2 Coatings"

American Society for Metals Meeting of Calgary Chapter, Calgary, Alberta, Canada, May 7, 1984:

G. M. Slaughter, "Materials R&D for Energy Applications"

Meeting of American Society of Lubrication Engineers, Chicago, Illinois, May 7, 1984:

C. S. Yust* and F. J. Carignan, "Observations on the Sliding Wear of Ceramics"

Seminar, Department of Metallurgical, Chemical, and Polymer Engineering, University of Tennessee, Knoxville, May 8, 1984:

R. L. Klueh, "Alloy Development for Fusion Reactors"

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Sixth International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Nagoya University, Nagoya, Japan, May 14–17, 1984:

R. E. Clausing and L. Heatherly (presented by J. B. Roberts), "Control of Surface Composition and Hydrogen Recycling by Plasma Conditioning"

Seminar, University of Tennessee, Knoxville, May 15, 1984:

J. M. Vitek, "Tempering Behavior of Ferritic Steel"

Institute of Electrical and Electronics Engineers Minicourse on Fusion, St. Louis, Missouri, May 17, 1984:

F. W. Wiffen, "Materials Requirements and Potential Solutions for Fusion Reactors"

Tristate Catalyst Symposium, Lexington, Kentucky, May 23, 1984:

A. G. Dhere,* R. J. DeAngelis, P. J. Reucroft, and J. Bentley, "Size, Morphology, and Substructure of Metal Particles in Supported Metal Catalysts"

Materials Science Seminar, 1984 Southeastern Section Meeting, Electron Microscopy Society, Birmingham, Alabama, May 24, 1984:

C. L. White, "Application of Surface Analysis in Materials Research"

Annual Meeting of the American Nuclear Society, New Orleans, Louisiana, June 3–8, 1984:

R. H. Cooper, Jr.,* and E. E. Hoffman, "Tantalum and Niobium Alloys for Space Nuclear Applications"

J. H. DeVan, "Materials Compatibility Considerations for a Molten Salt Fusion Breeder"

58th Colloid and Surface Science Symposium, American Chemical Society, Pittsburgh, Pennsylvania, June 10–13, 1984:

A. Bleier* and W. C. Hasz, "Implications of Charge Regulation to Concentrated Suspensions"

N. Strauss, T. A. Ring, H. K. Bowen, and A. Bleier,* "Interaction Energies and Pressures in Concentrated Electrostatically Stabilized Suspensions"

Meeting of the Atlanta Section of the American Society for Nondestructive Testing, Atlanta, Georgia, June 11, 1984:

J. H. Smith, "Ultrasonic Inspection of Stainless Steel Welds"

American Society of Mechanical Engineers Pressure Vessel and Piping Division Conference, San Antonio, Texas, June 17–22, 1984:

G. M. Goodwin* and R. K. Nanstad, "Effect of Temperature on the Stress-Relaxation Response of a Pressure Vessel Steel"

R. W. Swindeman, "Fatigue of Bainitic 2 1/4 Cr-1 Mo Steel Weldments at 482°C"

R. W. Swindeman, "The Response of Bainitic Low Alloy Steels to Nonsteady Loading at Elevated Temperatures"

R. W. Swindeman, "The Response of Ferritic Steels to Nonsteady Loading at Elevated Temperatures"

12th International Symposium on Effects of Radiation on Materials, sponsored by the American Society for Testing and Materials, Williamsburg, Virginia, June 18–20, 1984:

R. G. Berggren, J. J. McGowan, B. H. Menke,* and R. K. Nanstad, "Effects of Neutron Irradiation on Fracture Toughness of A 533 Grade B Class 1 Plate and Four Submerged-Arc Welds"

R. G. Berggren,* R. K. Nanstad, F. W. Stallman, and J. R. Hawthorne, "An Analysis of Charpy V-Notch Impact Toughness of Irradiated A 533 Grade B Class 1 Plate and Four Submerged-Arc Welds"

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W. R. Corwin,* R. G. Berggren, and R. K. Nanstad, "Charpy Toughness and Tensile Properties of a Neutron Irradiated Stainless Steel Submerged-Arc Weld Cladding"

K. Farrell and E. H. Lee,* "Ion Bombardment Damage in a Modified Fe-9 Cr-1 Mo Steel"

M. L. Grossbeck* and K. C. Liu, "Fatigue Behavior at 650°C of 20%-Cold-Worked Type 316 Stainless Steel Irradiated at 550°C in the HFIR"

L. L. Horton* and L. K. Mansur, "Experimental Determination of the Critical Cavity Radius in Fe-10% Cr for Ion Irradiation"

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E. H. Lee* and A. F. Rowcliffe, "The Temperature Dependence of Phase Compositions in Ti-Modified Austenitic Stainless Steels During Irradiation"

G. R. Odette,* P. J. Maziasz, and R. E. Stoller, "An Assessment of the Mechanisms Controlling Swelling Resistance of Titanium Modified Stainless Steels"

Seminar, Exxon Research and Engineering Company, Annandale, New Jersey, June 26, 1984:

C. J. Sparks, Jr., "X-Ray Probes for the Microcharacterization of Materials"

Third Annual Steam Generator Workshop, EPRI-NDE Center, Charlotte, North Carolina, June 26–27, 1984:

C. V. Dodd, "Improved Eddy-Current Inspection for Steam Generator Tubing"

Seminar, Ispra Nuclear Research Center, Varese, Italy, June 28, 1984:

N. H. Packan, "Pulsed Dual-Ion Irradiations of Stainless Steels"

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