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**Metals and Ceramics Division
Progress Report for Period Ending
June 30, 1985**

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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**METALS AND CERAMICS DIVISION PROGRESS REPORT FOR
PERIOD ENDING JUNE 30, 1985**

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Date Published - January 1986

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INTRODUCTION AND DIVISION OVERVIEW

The Metals and Ceramics Division is a broad, multidisciplinary research organization that encompasses virtually all elements of materials science and engineering. It provides materials support for the full range of Oak Ridge National Laboratory (ORNL) and Department of Energy (DOE) programs. The Division is structured around functional groups having capabilities that can be combined to attack large, complex problems.

The Division tends to emphasize high-temperature structural materials because of needs of ORNL and DOE. Activities range from fundamental theoretical and experimental studies of alloying behavior, through development of new materials, to establishment of engineering properties and appropriate data bases. Strong emphasis is placed on the development and transfer of technology to the private sector.

The multidimensional nature of the Division makes it difficult to describe its activities from any single point of view. A description of the functional organization often fails to reveal the programmatic interactions, and a programmatic description misses much of the depth of our functional capabilities. Moreover, some activities cross both functional and programmatic lines. In this report we present brief descriptions of our functional groups in Chapters 1 through 3. Program activities are reviewed in Chapter 4, and collaborative research facilities are highlighted in Chapter 5. The presentations are necessarily brief; details of the research activities can be found in periodic progress reports issued by the individual programs or in open literature publications and presentations, which are listed in Appendixes G and H.

Our work on nickel aluminide alloys illustrates the way in which the Division operates. About three years ago as part of our basic research program we discovered that small boron additions transformed polycrystalline Ni_3Al from a brittle compound unfit for structural applications to a material that exhibited 50% ductility in tensile tests at

room temperature. This material, which is oxidation resistant, has excellent high-temperature mechanical properties. The Fossil Energy, Conservation, and Gas Cooled Reactor Programs immediately saw applications for the material and provided funding to increase the development effort. In addition to alloy development work, corrosion, fabrication, and joining activities were undertaken. Basic research studies focused on the mechanism by which boron enhances ductility. We entered into cost sharing contracts with several industrial organizations to develop processes for producing the material on a commercial scale. An open meeting was held to discuss progress on the program, and numerous samples were sent for evaluation. We are now dealing with more than 20 organizations that are interested in either producing or using the alloys.

We have followed a similar approach for many years with our work in radiation effects. Basic research has been directed at understanding the mechanisms that control the processes occurring during irradiation and at devising principles for the design of radiation-resistant alloys. Applied activities, supported by the Breeder and Fusion Reactor Programs, have used this information in the development and qualification of structural materials. Interactions have benefited both the basic and applied efforts.

Our ceramic research also benefits from cross fertilization among the different programs in the Division. Our activities on whisker-reinforced ceramic matrix composites, on chemically vapor-deposited long-fiber-reinforced ceramic matrix composites, and on precipitate and metastable particle toughened ceramic composites have much in common. Our research in the immediate future in these areas will focus on understanding quantitatively the interface between the reinforcement or the metastable phase and the matrix to be able to tailor its chemistry and structure to optimize the strength and fracture toughness of these relatively new ceramic materials.

During the past year the ORNL High Temperature Materials Laboratory (HTML) was assigned to the Metals and Ceramics Division. V. J. Tennery, director of the HTML, is also manager of the High Temperature Materials Section in the Division. When the HTML building is complete early in 1987, the Ceramic Technology, Structural Ceramics, and Coatings and Tribology Groups will move into it. The building will also house several

user centers devoted to characterization and to physical and mechanical testing of ceramic materials. Several new facilities are under development. We began, during the past year, to establish new facilities for powder characterization and ceramic machining, which will extend our capabilities to characterize powder surfaces quantitatively and to machine monolithic ceramics and ceramic matrix composites precisely. We expect that the HTML will be a unique national resource and that it will provide a focal point for our ceramic research and development activities.

During the past year J. R. Weir, Jr., stepped down as director of the Division. The quality and enthusiasm of the staff, as reflected in the work reported here, is a strong testament to the leadership that Jim provided the Division over the past 12 years.

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-1366	Period Ending July 31, 1952
ORNL-1437	Period Ending October 31, 1952
ORNL-1503	Period Ending January 31, 1953
ORNL-1551	Period Ending April 10, 1953
ORNL-1625	Period Ending October 10, 1953
ORNL-1727	Period Ending April 10, 1954
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
ORNL-4770	Period Ending June 30, 1971
ORNL-4820	Period Ending June 30, 1972
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
ORNL-6084	Period Ending June 30, 1984

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 and commercializing new engineering alloys, and for determining and developing improved fabrication, joining, and nondestructive testing techniques to ensure the structural integrity of materials and components in specific applications. It comprises approximately 70 staff members, about half of whom are professionals. Research and development activities are carried out in six different laboratories, which bear the functional names Materials Compatibility, Materials Joining, Mechanical Properties, Metals Processing, Nondestructive Testing, and Pressure Vessel Technology. Additionally, divisional support for the Heavy Section Steel Technology (HSST) Program, two space nuclear projects, and the Steel Initiative 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 support of the fusion energy, fossil energy, waste management, conservation, and basic energy sciences programs. Related corrosion studies are also being conducted under subcontract to General Electric Company and Cabot Corporation.

Activities in the fusion energy program deal with the corrosion behavior of potential heat-transfer and tritium-breeding fluids. In the area of liquid metal corrosion, we characterized the dissolution of austenitic and ferritic steels by thermally convective Pb-17 at. % Li and

used lithium thermal convection loops to study the mass transfer of low-activation, Cr-Mn steels. We also completed an initial assessment of the susceptibilities of developmental austenitic alloys to intergranular corrosion in aqueous environments.

Corrosion studies supporting the development of fossil energy resources were divided between two tasks: corrosion of current collector materials in molten carbonate fuel cells and corrosion, erosion, and erosion-corrosion in coal combustion and conversion environments. We have completed our studies of the reaction paths of candidate current collector materials with LiKCO_3 salt films in CO_2 - CO - O_2 mixtures and have measured the solubility of Cr in LiKCO_3 melts as a function of CO_2 activity. On the basis of the results, we are testing an optimized set of Fe-Cr-Ni alloys under simulated fuel cell conditions. The second task involves the modification of a scanning electron microscope to permit direct observation of a sample while it is being oxidized (or sulfidized) or to permit study of a surface being impacted by erosive particles. In collaboration with the Basic Energy Sciences Program, the effect of surface treatments or modifications on the initial stages of oxidation are being assessed, and the effect on erosion mechanisms of particle velocity, impact angle, and sample surface treatment is being studied. Use of the oxidation system in combination with the erosive particle injection system will permit erosion-corrosion studies.

Other group project activities were in support of nuclear waste management and energy conservation. In support of the first area we continued our investigations of possible corrosion failure modes of candidate metallic waste containers in a basalt repository and extended the studies to include salt and tuff repositories. In support of energy conservation, we prepared a "white paper" defining critical corrosion issues that must be addressed within the energy conservation initiatives that have been set forth by the Department of Energy. Also, we assisted the ORNL Energy Division in the development of higher efficiency absorption refrigeration cycles by determining the corrosiveness of new working fluids that promise to be more efficient than the $\text{LiBr-H}_2\text{O}$ and $\text{NH}_3\text{-H}_2\text{O}$ systems presently in use.

During the past year we completed a "seed money" project to study the effect of surface pretreatment on development of protective oxide scales. We demonstrated that a more protective oxide scale could be produced by either oxidation or vacuum annealing pretreatments.

1.2 MATERIALS JOINING - S. A. David

In view of the wide variety of joining activities, both current and anticipated, the name of the group was changed from Welding and Brazing to Materials Joining. The group continues to conduct materials joining research and development for Basic Energy Sciences, Fossil Energy, Conservation, and Fast Breeder Reactor Programs.

The Basic Energy Sciences welding study has continued to investigate the phase stability of austenitic stainless steel welds, in particular, sigma-phase formation in austenitic stainless steel welds. The sigma-phase formation was found to be nucleation controlled. However, phase analysis showed that the long-range diffusion necessary to produce chromium-rich sigma phase plays only a secondary role in the transformation of ferrite to sigma phase. Work on the stability of ferrite in austenitic stainless steel welds has shown that, during aging, ferrite approaches metastable equilibrium independent of any subsequent transformation to sigma phase. This effect is being investigated further by evaluating the effect of cooling rate on the ferrite composition at room temperature. These results will be applicable to as-welded structures formed under different cooling conditions as well as ferrite-containing structures subjected to elevated temperature exposure such as during multipass welding. Work is also under way jointly with the Chicago Bridge and Iron Co. and the American Welding Institute to demonstrate the feasibility of welding thick-section steels by electron beam welding. Finally, solidification and subsequent solid-state transformation work is also under way to propose a unified theory of hot cracking.

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 coal conversion vessels. Filler wire for submerged arc welding and coated electrodes for

shielded metal arc welding have been developed and evaluated. Successful welds with acceptable mechanical properties have been achieved for both shielded metal arc and submerged arc welding. We are currently evaluating the weldability of two additional 3 Cr-1.5 Mo alloys. In a joint effort with the Conservation Program, activities are also under way to evaluate the weldability of ductile aluminides. Welding studies have shown that the tendency for heat-affected-zone cracking in Ni₃Al alloys containing 10% iron can be suppressed by keeping the boron concentration near 200 wppm. The results of hot ductility testing suggested that grain boundary cohesive strength increased with the lowered boron concentration, and this increased resistance to cracking. Efforts are under way to estimate the thermal stresses generated in the aluminides during welding and to more completely describe the heat-affected-zone cracking behavior.

The Conservation Program activities center around improving the efficiency of automotive heat engines, thus conserving fuel costs. An important technological advance was made recently when processes were demonstrated for brazing partially stabilized zirconia (PSZ) to nodular cast iron (NCI) at a temperature sufficiently low (735°C) to prevent degradation of the properties of NCI. The new process is called "The Active Substrate Process." The brazing is performed in vacuum and utilizes treatment of the ceramic surface with an active agent to trigger wetting and strong bonding, in conjunction with a ductile low-melting brazing alloy. Work is continuing to optimize the process parameters and to characterize the mechanical behavior and thermal aging effects.

The Breeder Reactor Program continues to study the weldability of modified 9 Cr-1 Mo steel. The effort for the past year was aimed at establishing the factors that affect the overall quality and notch toughness of submerged arc weld deposits of modified 9 Cr-1 Mo. Welding procedures and materials that will result in sound welds have been identified, and notch toughness has been improved. Future work will concentrate mainly on further improvements in toughness and thick-section welding.

Finally, the group also engages in a wide variety of service-oriented work to support a number of projects in other divisions related to the Fusion Energy Program and Y-12 Development Projects. Part of the Fusion

Energy effort involved joining activities for the Large Coil Program, especially the General Electric/UCCND coil fabricated at the Oak Ridge Gaseous Diffusion Plant and the Westinghouse (East Pittsburgh) coil. The major Y-12 development project resulted in the design, fabrication, and implementation of a new weldability test for thin sheet materials.

1.3 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 12 months we received support from the following programs: Liquid-Metal Reactor, 35%; Gas-Cooled Reactor, 18%; Fossil, 18%; Conservation, 10%; Space Nuclear Power, 10%; Fusion, 3%; and miscellaneous service, 16%. 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.

Liquid-metal reactor work continued efforts to obtain data on various mechanical properties such as long-term creep and fatigue for types 304 and 316 stainless steel and modified 9 Cr-1 Mo steel. Increased effort was directed toward characterization of cast and weld metals of austenitic stainless steel because of their complex microstructures in comparison with wrought materials. We continued 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. Biaxial fatigue tests continued at elevated temperature on several wrought metals including modified 9 Cr-1 Mo steel 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 with a unique extensometer developed at ORNL. A 1985 IR-100 Award will be awarded for the development of this extensometer. All liquid-metal breeder reactor work is currently scheduled for phase-out during FY 1986.

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 utilities (United Kingdom and Canada), three domestic utilities, and several foreign laboratories are cooperating in the evaluation of this material. Materials data were submitted to the American Society for Mechanical Engineers Code formulating bodies. Code approval for Section I and Section VIII was obtained.

Many pages of material properties and behavior were prepared by our Data Analysis Center for entry into the *Nuclear Systems Materials Handbook* in support of liquid-metal reactor development.

Data development and analysis for the materials technology to design and license HTGR cogeneration and reformer systems emphasized collection of 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 (including decarburized material), and a number of advanced alloys.

Work continued in the characterization of commercial castings in support of fossil materials development. This effort included mechanical property (creep, tensile, and impact) and microstructural characterization of materials including modified 9 Cr-1 Mo steel, CF8 and CF8M stainless steels, and 2 1/4 Cr-1 Mo steel.

A plan was developed for the investigation of candidate alloys for advanced steam cycle superheaters and reheaters. The candidate alloys are modifications of steels in four categories: type 316 stainless steel, type 310 stainless steel, alloy 800, and aluminum-bearing austenitic stainless steel. Performance criteria were established in terms of strength, weldability, metallurgical stability, fireside corrosion resistance, and steam-side corrosion resistance. Many laboratory- and commercial-sized heats will be melted and subsequently tested so as to provide a basis for commercialization by about 1990.

We continued work on a conservation program to develop electrical and mechanical properties of candidate polymeric materials for dielectrics. Our objective is to develop mechanical properties of candidate polymers and to investigate long-term degradation in the presence of anticipated environments.

Creep testing of refractory metal alloys continued in support of the Space Nuclear Power System (SP-100) Program. Alloys under test include Nb-1 Zr, PWC-11, Mo-11 Re, and Mo-13 Re with test temperatures ranging from 977 to 1427°C under high-vacuum conditions.

Work was initiated in January 1985 on the Steel Initiative. The main objective of the Steel Initiative task is to develop innovative (leap-frog) technologies for the making, shaping, and treating of steel. The ORNL task deals with the "direct processing of near net size casting to final product" and is discussed further in Section 4.11, Steel Initiative.

1.4 METALS PROCESSING - R. L. Heestand

Iridium containment fabrication activities in support of space and terrestrial isotope power supply systems were directed toward process improvements to reduce delamination defects in the rolled sheet. Casting iridium billets by vacuum consumable arc melting followed by extrusion and hot and cold rolling to sheet yielded iridium blanks with no defects detectable by ultrasonic or dye-penetrant inspection. The process also reduces costs by reducing casting time, eliminating frames, and reducing sampling and chemistry.

Refractory alloys were fabricated for the SP-100 Space Nuclear Program for reactor irradiation tests. Efforts included the hot extrusion of W-25 Re and ASTAR-811C to rod, tube shells, and rectangular sheet bar. Rolled sheet for tensile, bend tests, and Charpy test irradiation specimens were rolled and machined from W-25 Re, ASTAR-811C, PWC-11, Cb-1 Zr, and T-111. Tubing of W-25 Re, PWC-11, and T-111 was also supplied. An inventory of the refractory metals for irradiation testing components was also maintained.

Post-irradiation evaluation of irradiated high-uranium-loaded oxide, aluminide, and silicide aluminum fuel plates and elements continued. This program is directed toward reducing enrichment levels of test reactor fuels to less than 20% ^{235}U , thus requiring an increase in the total uranium loading.

Assistance to the Alloying Behavior and Design Group and to the Steel Initiative was provided. Scaled-up induction melting and casting was initiated to study casting variables and increase the amount of material available for testing. Requests for more than 800 fabrication orders, 500 melts, and 125 extrusions were fulfilled during this reporting period.

1.5 NONDESTRUCTIVE TESTING - R. W. McClung

The Nondestructive Testing Group develops new or improved methods of nondestructive testing 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 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 Nuclear Regulatory Commission (NRC).

A major activity for DOE has been on the Breeder Reactor Materials Program. Ultrasonic signal processing techniques were investigated and developed 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 after initial studies on stainless steel plate. For the Clinch River Breeder Reactor (CRBR) steam generator, we completed a report 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 in-service inspection techniques for double-wall tubing

for a Westinghouse alternative steam generator design. A unique pulsed magnetization eddy-current instrument and technique were developed for the ferromagnetic tubing. We also provided technical support to W-NCD for training for the operation and troubleshooting of a microfocus rod-anode X-ray unit for radiography of tube-to-tubesheet joints.

For the DOE Office of Fusion Energy, we prepared a report on the development of 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 the technical support for on-line computer-based eddy-current equipment installed at Oxford-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 prepared a report on advanced ultrasonic techniques 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 developed techniques in ultrasonics and radiography for examination of miniature thermoelectric devices (and subcomponents) for extraterrestrial space probes and provided technical support for examining alloys and graphite components for space nuclear systems. Technical studies and developments were performed to increase by a factor of 4 the sensitivity of ultrasonic examination of iridium alloy components for isotopic thermal generators.

Initial studies were begun and equipment assembled for development of high-frequency (e.g., 100-MHz) ultrasonic techniques for structural ceramics and ceramic joints. Work has begun on an assessment report on material characterization and nondestructive examination of structural ceramics. A new program with the ORNL Environmental Sciences Division for the Office of Health and Environmental Research is developing quantitative low-voltage radiographic techniques for the evaluation of wood samples to determine forest response to increased atmospheric carbon dioxide.

Technical consultation and support were provided to the program management staff for the Fossil Energy Materials Development Program and for an analysis of casks for spent fuel elements. Technical assistance in multifrequency eddy-current instrumentation and technology was provided to several DOE and other laboratories.

A major activity for NRC reactor safety research was development and improvement of multiparameter multifrequency eddy-current techniques for the in-service inspection of light-water-reactor steam generators. In related activities, we provided technical assistance to Pacific Northwest Laboratory in evaluation of steam-generator tubing for intergranular stress-corrosion cracking. Technical activities for the Heavy-Section Steel Technology Program of the NRC involved advanced nondestructive examination of pressure vessel sections to assess preservice as-fabricated flaws. Another activity was for interaction with the American Society of Mechanical Engineers Code committees for 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 technical support for programs at the Oak Ridge Y-12 and Gaseous Diffusion Plants.

1.6 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 the Nuclear Regulatory Commission and the Department of Energy. We are currently emphasizing the materials property needs for the Heavy-Section Steel Technology (HSST), Fossil Energy Materials, High-Temperature Reactor (HTR), Magnetic Fusion Energy, and Space Reactor Programs and for a National Laboratory-Steel Industry Steel Initiative.

For the HTR Structural Materials Program, equipment was designed and/or assembled for conducting investigations of fracture toughness, fatigue crack growth rate, and creep crack growth rate at temperatures up to about 600°C. Procedures were developed to utilize a dc-potential drop technique for monitoring of crack extension, and data were obtained for annealed alloy 718.

Under the HSST Thermal Shock Program, fractographic studies were conducted for thermal shock experiment 7 (TSE-7) and pressurized thermal shock experiment 1 (PTSE-1). The results from those structural tests and companion laboratory crack arrest specimens show no indication of

conversion from cleavage to ductile tearing before arrest. Investigations are continuing in the area of lower-bound fracture toughness with the ultimate goal of prediction of thick-section component fracture toughness with small laboratory test specimens.

An HSST task to investigate effects of stainless steel weld overlay 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 and includes the study of irradiation effects on cladding. 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 results showed that good quality stainless steel cladding is not significantly degraded by neutron irradiation at light-water reactor fluences. However, the toughness is severely degraded when the cladding is produced by procedures resulting in high dilution of the base metal. The irradiation program is continuing with irradiations of cladding produced with the three-wire series-arc process.

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 C2 (A 533 grade B class 1 steel) for reference purposes, four state-of-the-art submerged-arc welds with copper contents from 0.04 to 0.12%, and material with low upper-shelf toughness from the Federal Republic of Germany. Capsule irradiations were completed in July 1982. All testing of U.S. steels has been completed, and it demonstrates that low copper content and modern welding techniques produce low-alloy steel welds with low sensitivity to neutron irradiation.

A new HSST irradiation project has been initiated to examine the upward temperature shift of the K_{IC} and K_{IS} 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 began in the Oak Ridge Reactor in May 1984 and are scheduled for completion in April 1986.

Studies on the Fossil Energy Materials program have emphasized mechanical property characterization of 3% Cr-1.5% Mo-V steels for gasification pressure vessels. Tensile properties, Charpy V-notch impact toughness, and J -integral resistance curves were determined over a wide temperature range for various heats. The materials have been postweld heat treated at varying combinations of temperature and time to determine the optimum conditions.

Subsize Charpy impact specimens of irradiated ferritic first-wall materials for the Magnetic Fusion Energy Program were tested. Preliminary results have shown that the $n-\alpha$ reaction of nickel-doped steels in a fission spectrum can be used to produce helium embrittlement similar to that which would occur in a fusion reactor.

The Steel Initiative Program, started this year, is studying the casting of near-net-thickness steel plates and their subsequent fabrication into acceptable steel sheet.

2. HIGH TEMPERATURE MATERIALS

V. J. Tennery

The High Temperature Materials Section has as a principal objective the understanding and control of the microstructure and thereby the properties of ceramic and metallic materials. Emphasis in the past has been on materials for high-temperature mechanical applications, but, during this year, research activity has also been initiated in electronic ceramics including varistors and perovskite-based nonlinear dielectrics.

During the year, several of our research results have received international recognition. Our continued research on ordered intermetallic alloys attracted strong interest from the industrial community as evidenced by the attendance at a workshop on this subject held in Oak Ridge in the fall of 1984. The research in this area sponsored by the Cabot Corporation is continuing and has resulted in identification of alloy systems of interest to Cabot. During this year, our research has resulted in the first reported test of a thermodynamic theory of grain boundary cohesion to explain the behavior of the ductilizing role of boron in these alloy systems. We also observed direct experimental evidence of phase separation in amorphous ZrNi alloys wherein the phase compositions are similar to the crystalline phases present in equilibrium material.

Our research on ceramic matrix composites has progressed well with the result that we have found practical processing means for densifying many of these complex high-temperature materials. Composites of alumina reinforced with SiC whiskers have been sintered to near theoretical density with pressureless sintering at whisker contents to slightly greater than 10 vol %, and they have very attractive mechanical properties. Partially stabilized zirconia utilizing ceria and sol-gel processing has resulted in ceramics with very high fracture toughness and high strength.

This work was conducted with an industrial visitor. Our ceramic composites consisting of chemically vapor deposited SiC matrices and continuous SiC fibers have high flexure strength and strains before fracture (several percent in some cases). Our ceramic tribology research has resulted in better understanding of the interface region between materials during sliding contact in various atmospheres and how surface damage affects the lifetime of various ceramics of interest for advanced heat engine applications.

The Section now includes the High Temperature Materials Laboratory (HTML). Construction of this national facility started in February 1985, and an inauguration ceremony on May 17 was attended by a large number of industrial and governmental visitors. Procurement of the research instruments for the four user centers in the HTML is under way, with principal activities focused on long-lead-time items.

Members of the Section are involved in both the management and research activities of the conservation programs Ceramic Technology for Advanced Heat Engines and Materials for Energy Conversion and Utilization Technology, as well as the Fossil Energy Materials Program. Our staff manage many subcontracts in these programs and conduct in-house research on toughened ceramics, joining, environmental effects, coating synthesis, and alloy development. Significant work is also under way as part of a new International Energy Agency agreement on advanced ceramics between the United States, the Federal Republic of Germany, and Sweden.

2.1 ALLOYING BEHAVIOR AND DESIGN - C. T. Liu

The primary goal of the Alloying Behavior and Design Group is to generate understanding of alloying behavior, and of structure-property relationships in alloys, so that the design principles for new alloys to meet specific energy technology needs can be developed. Group activities focus 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 materials through control of alloy composition, microstructure, and processing techniques.

The alloy design program addresses the development and application of principles for design of high-temperature structural alloys based on intermetallic compounds. Many of these strongly ordered intermetallic compounds possess attractive high-temperature properties; however, their development for structural applications has been seriously retarded because of low ductility, often resulting from grain boundary weakness. We have used both macroalloying and microalloying to improve the ductility and fabricability of several intermetallic alloy systems. Macroalloying is aimed at controlling the bulk properties of the ordered crystal structures, and it has been successfully applied to alloys based on the compounds Ni_3Al , $(\text{Fe},\text{Co},\text{Ni})_3\text{V}$, Fe_3Al , and Ni_3Si . Microalloying involves trace alloying additions to influence the properties of lattice defects (e.g., vacancies, dislocations, and grain boundaries). We had previously demonstrated a marked improvement in grain boundary strength resulting from small boron additions (0.1 wt %) to Ni_3Al , where the boron was observed to segregate strongly to grain boundaries. This effect was puzzling because most grain boundary segregants embrittle rather than strengthen grain boundaries. During this past year we have studied free surface segregation in boron-doped Ni_3Al , and we found the grain boundary and free surface segregation behavior of boron-doped Ni_3Al to be in substantial agreement with a thermodynamic theory of grain boundary cohesion first put forward by J. R. Rice in 1976. This is significant because it is the first direct confirmation of Rice's theory for the case of a strengthening segregant. Should our ongoing work indicate that Rice's theory is broadly applicable, it would constitute a very powerful design principle for solving grain boundary weakness problems in intermetallic alloys. We have also made significant progress in understanding the role of environment on high-temperature tensile ductility of Ni_3Al type alloys and developed means of minimizing detrimental effects of certain environments.

The deformation and fracture program investigates the mechanisms of deformation and fracture of structural alloys at elevated temperatures. We are completing a detailed study of trace element effects on creep cavitation of model austenitic stainless steels. Research on high-temperature

deformation and fracture of boron-doped Ni_3Al , including grain boundary sliding, creep cavitation and deformation, and diffusion creep has been initiated during the past year. Theoretical modeling of slip band interactions with grain boundaries at elevated temperatures has been carried out and will be applied to creep cavitation in boron-doped Ni_3Al .

The emphasis of the metastable materials program is on structure-property relationships in metastable metallic materials prepared by rapid quenching from the liquid or vapor states. Compositional effects on physical properties derived from low-temperature specific heat measurements and differential scanning calorimetry of the thermal relaxation and crystallization processes are studied in conjunction with X-ray diffraction, electron microscopy, and small-angle neutron and X-ray scattering measurements of the glass and its crystallization products. Phase separation and crystallization of liquid-quenched metallic glasses in the ZrNi system have been studied. We have concluded that phase separation in compositions near the eutectic at 63.5 at. % Zr results in glass phases similar in composition to the crystalline phases (one stable and one metastable) that form on crystallization. This correspondence between amorphous and crystalline phases strongly suggests a structural similarity. The effects of microalloying on the mechanical and magnetic properties of iron-based metallic glasses are studied. These technologically important materials exhibit very soft ferromagnetic properties, indicating that their use in magnetic cores in motors and transformers would lead to improved operating efficiencies. We have found that microadditions of cerium, which is used to reduce oxygen and sulfur in glasses, strongly retard the troubling embrittlement of some of these glasses during noncrystallizing anneals required to optimize their magnetic properties. The hysteretic magnetic properties are also affected, indicating that low concentrations of oxygen and/or sulfur affect the state of stress and possibly the medium-range structure of the glass. We conclude that annealing embrittlement in many iron-based glasses is caused by segregation of oxygen and/or sulfur to as yet unidentified features in the glass that are involved in plastic deformation or brittle fracture. These results indicate that microalloying is an important new tool with which to

study structure-property relationships in these materials and to improve their technologically important properties.

2.2 CERAMIC TECHNOLOGY - A. J. Moorhead

Conventional ceramics show great promise for many applications because of their high-temperature strength and hardness and their resistance to corrosion and oxidation. However, they have one major drawback that has hindered their use in advanced structural applications - a lack of adequate fracture toughness. We have developed a unique ceramic-matrix composite that has all the desirable attributes of a conventional ceramic including high strength (to at least 1000°C) but is *twice* as tough. This alumina-based ceramic material reinforced with silicon carbide whiskers has been shown to be more resistant to slow crack growth, creep, and thermal shock than is monolithic alumina. Recently, fabrication techniques have been developed to pressureless sinter composites with up to 10 vol % SiC whiskers to nearly full density. Those techniques are necessary to economically fabricate complex shapes of this composite. Cutting tools made of this material are being marketed by Greenleaf Corporation, and a number of manufacturers are considering the composite for components of heat exchangers and advanced heat engines. This composite has also shown promise in preliminary tests as a prosthetic material. Toughening of mullite and alumina-zirconia matrices also has been demonstrated this year.

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 work is directed toward development and scale-up of an industrially attractive sintering procedure.

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 to improve the toughness of the electrolyte and minimize degradation and premature failure. We have successfully made ceramic electrolytes that duplicate the compositions of single crystals that have attractive low-temperature conductivity. Work is under way to characterize the properties of these electrolytes and optimize their processing.

Our work on electronic materials has recently been expanded with the initiation of three new projects in the areas of ceramic dielectrics and gas sensors. Future work on magnetic materials (ferrites and garnets) is also being planned.

Metal-matrix composites with high-strength intermetallic alloys (such as Ni₃Al) as the matrix phase are under development for applications requiring high-temperature strength and oxidation resistance. One composite has a room-temperature microhardness about twice that of Ni₃Al. High-temperature mechanical properties are being determined to assess the ability of this composite to retain its strength at elevated temperatures.

Silicon carbide is a candidate material for components of heat engines and waste heat recuperators. Our efforts to develop a process for synthesis of high-purity, ultrafine, sinterable SiC powder have continued during this report period. SiC powders were synthesized from such inexpensive and easily processed raw materials as carbon black and mineral silica. High specific surface areas (10-20 m²/g) were obtained; these areas are equivalent to those previously obtained when using fumed silica and pitch or phenolic resin as the powder precursors and to those of commercially available SiC powders. A powder processing procedure adaptable to industrial scale-up was developed for this material and successfully transferred to ART, Inc. By using our procedure, ART, Inc., has produced sinterable powders of exceptionally high purity (<100 ppm total cations) at a pilot scale rate (~10 kg/h) in a rotary furnace.

Composites of SiC and TiC hot pressed with carbon and aluminum additions exhibit room-temperature strength and fracture toughness values as much as 50% higher than those 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. A detailed processing study showed that the microstructures and mechanical properties of these composites were sensitive to milling conditions and carbon source.

A state-of-the-art powder characterization laboratory is being assembled. Equipment has been procured for determining BET gas adsorption, gas permeability, zeta potential, powder titration, particle size by light scattering, and slurry viscosity. Additional equipment has been specified for determining pore size distribution, infrared spectra, particle size by sedimentation, and mechanical properties of powder compacts. When complete, this laboratory will be one of the premier ceramic-powder characterization facilities in the country.

The carbon-bonded carbon-fiber insulation team has selected rayon filament from a new supplier as the source for the precursor for carbon fiber to be used in future production of flight-quality hardware. Phenolic fibers were considered and rejected when preliminary evaluation indicated that the advantages to be gained in thermal conductivity did not warrant further investigation, and the fibers could not be made commercially available in the proper diameter.

Steady-state thermal conductivity measurements using a radial heat flow technique are in progress. These measurements are required to correlate directly measured conductivity to the less expensive and commonly used diffusivity-derived measurements. Tests have been completed through 1000 K in several gaseous atmospheres over a range of pressures from 9.1×10^2 to 1.0×10^5 Pa (0.009–1.0 atm). The data obtained to date are reproducible and self-consistent.

Dimensional changes under irradiation and the associated effects on physical properties of graphite to full-life fluences were generalized for anisotropic grades of graphite. The results of this study were applied to the core-block graphite structure of the N-Reactor to consider the merits and risks of a prolonged extension of the operational life of the reactor. It was shown that estimates of behavior from test-reactor specimens were in good agreement with actual experience. It is also indicated that the vertical stack growth will be the limiting consideration in estimating the useful life of the core graphite.

Nondestructive testing techniques coupled with the principals of fracture mechanics have been used successfully to evaluate experimental graphites for the high-temperature gas-cooled reactor. The sonic procedures yielding the elastic constants, estimates of the mean fracture strength, and variability were validated by destructive tensile testing in both axial and radial directions. These results indicate that quality assurance of large graphite moderator and reflector blocks can be accomplished by nondestructive testing.

Properties such as hardness, high melting temperature, high electrical conductivity, and compatibility with various liquid metals make titanium diboride (TiB_2) a candidate for such applications as cutting tools, armor, and cathodes in Hall-Heroult aluminum-refining cells. An ORNL-developed process using nickel as a sintering aid allows TiB_2 to be hot pressed at $1550^\circ C$ (instead of $\sim 2000^\circ C$ if nickel is not used). The lower processing temperature causes less grain growth and associated microcracking, thereby resulting in better strength and toughness of the dense ceramic. We transferred this technology to two industrial fabricators who then fabricated nominal $15 \times 15 \times 2.5$ cm and $25 \times 25 \times 5$ cm tiles to be tested ballistically for armor applications. The smaller tiles performed well in ballistics tests; the larger tiles have yet to be tested. A cost analysis of tiles fabricated with and without the nickel sintering aid is in progress.

Silicon carbide ceramics are being used as heat exchanger tubes and structural components in waste heat recuperators intended for application on various industrial furnaces such as steel reheat, steel soaking pit, and aluminum remelt furnaces. Exposure tests have revealed that SiC ceramics are corroded by some furnace atmospheres. Our recent laboratory tests have identified halide compounds as the expected corrodents in aluminum remelt furnaces. The corrosion mechanism inferred from the results and from thermodynamic considerations involves formation of volatile silicon halides. Knowledge of corrosion mechanisms and rates is needed to project component lifetimes and for devising solutions to corrosion problems, such as coatings.

We have developed a broad range of experimental filler metals that will directly braze structural ceramics such as partially stabilized

zirconia (PSZ), high-purity alumina, our SiC-whisker-reinforced alumina composite, and sintered α -SiC. Our filler metals of composition Ag-31 Cu-20 Ti and Cu-20 Au-18 Ti, at. %, produced ceramic-ceramic brazements that had flexural strengths in air greater than 100 MPa at 600°C. Both compositions show promise for meeting the ceramic joining needs of the uncooled diesel engine.

Most recently a new series of low-brazing-temperature ($\leq 800^\circ\text{C}$) filler metals was developed. These quaternary alloys have been shown to have wetting and bonding behavior superior to that of ternary titanium-containing alloys. In brazed alumina and PSZ flexural specimens tested in air at 400°C, most failures occurred in the ceramic and not in the braze joints.

Nickel-base brazing filler metals containing aluminum as the major alloying addition have also been developed. These alloys wet and strongly adhere to oxide- and carbide-base ceramics without the need for reactive metal additions that heretofore had been considered a prerequisite in a filler metal for direct brazing of ceramics.

2.3 COATINGS AND TRIBOLOGY - V. J. Tennery, D. P. Stinton, and C. S. Yust

A process was developed for the fabrication of fiber-reinforced SiC composites by chemical vapor infiltration. Ceramic composites are fabricated by infiltrating low-density fibrous structures with gases that decompose to deposit as solid phases on and between the fibers, forming the matrix of the composite. This comparatively low-stress, low-temperature process avoids the mechanical, thermal, or chemical damage to the fibers caused by many ceramic fabrication processes. Infiltration times for the low-density fibrous structures were reduced significantly from previous processes by simultaneously utilizing a thermal gradient and forced gas flow. Synthesis of composites in this fashion produced specimens with flexural strengths as high as 520 MPa and strain tolerances which significantly exceeded that of monolithic SiC. The flexibility of the process was demonstrated in cooperative work with Babcock and Wilcox by infiltrating their tubular preforms (4.5 cm diam $\times$ 13 cm long) to a density of 85% of theoretical density.

Toughened ceramic composite coatings were produced by the simultaneous chemical vapor deposition of a SiC matrix and a dispersed phase of TiSi_2 . Fracture toughness values for these composite coatings approached $7 \text{ MPa m}^{1/2}$ at 25°C , which is significantly higher than that of monolithic SiC. Deposition of coatings within a fluidized bed produced a finer and more uniformly dispersed second phase that is expected to improve mechanical properties.

Chemical vapor deposition of erosion-resistant TiB_2 coatings was investigated for use in highly erosive environments. Coatings deposited onto cemented tungsten carbide substrates exhibited little or no wear during accelerated erosion testing. However, the process could not be controlled sufficiently to reproducibly synthesize highly erosion-resistant coatings. TiB_2 coatings that exhibited little or no wear were also applied to cast-iron substrates.

Low-level liquid and sludge wastes generated at ORNL are solidified within a cementitious grout and disposed of by shale fracturing (hydrofracture). Grouts containing simulated wastes were previously characterized to verify that radionuclides had not migrated into the surrounding shale formation. Recent coring operations at the old hydrofracture site recovered samples from 28 actual injections that contain significant quantities of ^{137}Cs and ^{90}Sr . Five samples are being sectioned and mounted within a remote glove-box environment and will be characterized for radionuclide migration.

The tribology studies in progress are directed toward an evaluation of the friction and wear behavior of ceramics, including an understanding of wear mechanisms. A major focus is on ceramics of interest for advanced heat engines. Pin-on-disc wear tests have been continued on several candidate engine ceramics under test conditions selected to produce minimal wear. These specimens, which include partially stabilized zirconia, toughened alumina, and silicon nitride, have been studied for evidence of the initial damage processes. The observations demonstrate that the unlubricated sliding of these ceramics on themselves results in formation of a very fine particulate debris at a very early stage of sliding. Microadhesive or microfracture processes produce debris particles as small as 10 nm ($100 \text{ \AA}$) in diameter that are agglomerated and compressed to form an

adhered debris layer along the wear track. In the case of partially stabilized zirconia, there is evidence of debris particle formation at interface temperatures as great as 2000°C. Chromia-based coatings proposed as cylinder wall wear surfaces have also been tested in unlubricated sliding against sectors of chromium-plated piston rings. Pin-on-disc tests at room temperature and at 300°C show that the ring sectors wear preferentially to the chromia coating and that the friction coefficient for this sliding pair is 0.30 (20°C) to 0.34 (300°C). The unlubricated sliding of a spherical diamond-tipped pin on a nickel-ion-implanted TiB_2 surface produces a layer of adhered debris from the diamond tip on the wear track. The friction coefficient for this room-temperature interaction is 0.02 to 0.04.

A workshop on Tribological Test Devices and Procedures for Ceramics was planned, organized, and conducted in cooperation with the National Bureau of Standards and the Department of Energy. The workshop was held on April 23-24, 1985, and attracted almost 100 persons from industry, academia, and governmental organizations. The purpose of the workshop was to assemble a cross section of the tribology community to assess the need for and desirability of introducing standardized wear tests. Extended discussion indicated that a need for standard test procedures and selected standard tests is recognized. It was recommended that an initial set of test standards be formulated. A draft of the summary report of the workshop discussions has been prepared, is being reviewed, and will be distributed nationally.

2.4 STRUCTURAL CERAMICS - P. F. Becher

Research in the Structural Ceramics Group focuses on understanding (1) the chemistry of particulate ceramics (e.g., colloids) and dispersion-consolidation phenomena, (2) the mechanisms of densification and microstructural evolution in consolidated particulate systems, and (3) the mechanisms of crack growth and toughening in various environments in the resultant ceramics.

In the Materials Sciences Program, we have addressed the solid-state sintering processes involved in the densification of submicron TiB_2 powders in collaboration with studies of high-temperature chemical

reactions conducted in the Chemistry Division at ORNL. Fully dense, fine-grained TiB_2 can be achieved by sintering; however, the densification and grain growth mechanisms (e.g., mass transport processes) are sensitive to the oxygen concentration on the surface of the TiB_2 particulates. This effect is modified by reduction reactions at high temperatures due to oxygen removal while the compacts still have open porosity. Oxide species were also shown to influence the grain boundary phases formed during liquid-phase sintering of TiB_2 powders as described in a detailed analysis of the overall processes involved in phase formation in TiB_2 densified via liquid-phase processes.

Control of the sintering and microstructural evolution in ceramics requires that we understand the synthesis of particulates and the dispersion-consolidation behavior of particulate (powder) systems before sintering. We have shown that surface forces on particulates can be modified by regulating surface charges through the adsorption-desorption of ionic species or polymers. These processes modify powder agglomeration/dispersion and consolidation or particulate packing. However, these processes are influenced by particle size and size distribution, requiring that we understand how to control particulate synthesis. We gained that understanding in studies of the growth of ZrO_2 colloids. It allows us to minimize the energy (thermal) required for densification and to control microstructure (e.g., grain size, second-phase particle size, and spatial distribution). Our research strives to utilize this understanding in developing (1) models of the mechanisms of consolidation, sintering, and microstructural evolution, and (2) materials with regulated microstructures for studies of mechanical behavior in toughened ceramic systems.

Experimental and modeling studies of zirconia-toughened aluminas were used to describe the toughening behavior related to the stress-induced tetragonal to monoclinic transformation in ZrO_2 . This work was extended to model the role of the size of the tetragonal particulates and the solute content on the transformation stress and transformation zone size associated with fracture in partially stabilized zirconias and

fine-grained tetragonal zirconias through collaborative studies with the Chemistry Division at ORNL, CSIRO (Melbourne, Australia), the 3M Company, and the Chemical Technology Division at ORNL.

Work in the Fusion Energy Program included a description of the stresses developed in polycrystalline alumina and berylia ceramics because of microwave heating for various service conditions, and it indicated that temperature and environment can strongly influence the time to fracture under tensile stress conditions. These studies now focus on the behavior of single-crystal α -alumina, which is a candidate window material for microwave plasma-heating devices of very high power. Also, we recently completed studies for the Fossil Energy Materials Program that described changes in the fracture strength of SiC ceramics exposed to air and to basic coal slags in air for a range of elevated temperatures as a function of exposure time and applied tensile stress. Included were some of the first interrupted static fatigue measurements for sintered α -SiC conducted anywhere for times to 1000 h at temperatures of 1150 to 1300°C. This work showed that α -SiC ceramics have significantly higher fracture strength (~30%) when subjected to long-term static stress at high temperature compared with annealing under zero applied stress. This phenomenon is opposite to that observed in most ceramic materials for which such data have been reported.

Finally, in the Ceramic Technology for Advanced Heat Engines Program, we have completed studies of MgO partially stabilized zirconias that describe the long-term stability (up to 1000 h of applied stress) of the mechanical properties (fracture strength and toughness) at temperatures up to 1000°C. In cooperation with the processing research in the Ceramic Technology Group, we have conducted work on composites, including selected ceramic matrices, to identify the toughening mechanisms in SiC-whisker-reinforced ceramics (e.g., alumina and mullite). The results are being used to assess the influence of matrix properties and composition in the tailoring of properties in these high-fracture-strength high-toughness composites.

2.5 METALLOGRAPHY AND MICROANALYSIS - R. S. Crouse

The Metallography Group performs research on optical microscopy, general metallography, and electron-beam microanalysis of both alloy and ceramic materials. Work is performed in collaboration with materials researchers from ORNL, other federal laboratories, and industrial firms. During this reporting period, the group prepared approximately 4000 specimens, processed 6800 black-and-white negatives and 650 color negatives, and prepared 1660 slides and viewgraphs.

2.5.1 General Metallography - R. S. Crouse and B. C. Leslie

The Engineering Technology Division of ORNL is engaged in large-scale creep and stress rupture tests of engineering alloys that are of long-term duration (several thousand hours). At specified intervals, the Metallography Group field team polishes, etches, and replicates the tests in situ to follow changes in the alloy microstructure.

Reactor-core meltdown experiments in the Chemical Technology Division are examined metallographically to characterize the reactions that take place between the fuel element components. Characterization utilizes microanalysis as well as optical metallography.

A new etchant for the long-range-ordered alloy Ni_3Al was developed this year. The alloy tends to develop strains from this etchant, which can be removed by swabbing with a 1% aqueous solution of CrO_3 .

A major change in specimen polishing routine was required by the many ceramic samples now being processed. Two intermediate steps were introduced requiring 3- μm and 1- μm diamonds on pelion cloth before final polishing on 0.5- μm diamonds. Total polishing time was greatly reduced, and results were improved significantly.

2.5.2 Electron-Beam Microanalysis - R. S. Crouse, T. J. Henson, and B. C. Leslie

The microanalysis capabilities of the Metallography Group were extended this reporting period with the addition of a computer-based energy-dispersive X-ray analytical system to the scanning electron microscope. This system complements the microprobe by providing rapid

qualitative and semiquantitative chemical analyses of a variety of materials that are unsuited to the microprobe.

Microprobe analyses were performed on a variety of mineral samples in support of the research efforts of the Environmental Sciences Division concerned with disposal of high-level nuclear wastes. Hanford basalts and Chattanooga shales were characterized.

The microprobe was used to follow the diffusion of VB_2 , CrB_2 , and ZrB_2 in TiB_2 as those compositions in these systems were annealed at increasingly higher temperatures to attempt to achieve solid solution. X-ray dot mapping was employed for these analyses. At 1600°C ZrB_2 appeared to have completely diffused in TiB_2 , but VB_2 and CrB_2 required 2200°C to achieve complete diffusion. The unique ability of the microprobe to analyze for oxygen identified an observed secondary phase in the zirconium-containing system as ZrO_2 . This research was performed in collaboration with the Physical Properties Group.

Samples of Chattanooga shale were irradiated in the High Flux Isotope Reactor and subsequently autoradiographed. By matching the exposed areas on the autoradiographs to microstructural features of the sample observed in the microprobe, we were able to identify and quantify elemental species in the shale. This identification is acutely important in the evaluation of the shale for high-level radioactive waste fixation.

Part of the nickel aluminide alloy development involves the investigation of the effect of minor additions of elements such as hafnium. In these alloys we determined that an unusual grain boundary phase was hafnium rich by microprobe techniques.

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 50% of our support is from the Office of Basic Energy Sciences, 25% from the Office of Fusion Energy, and 25% from the Offices of Fossil Energy, Conservation and Renewable Energy, Space Nuclear Reactor Programs, and the Gas-Cooled Reactor Program. Basic Energy Sciences' research on alloy theory, characterization of the structure and chemistry of materials with X rays, radiation effects on materials, and electron microscopy are centered in the Materials Science Section. Research supported by the Office of Fusion Energy, which is also centered in the Section, includes development of improved alloys for structural applications, interaction of the plasma and materials, and radiation effects in ceramic materials.

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 and through Oak Ridge Synchrotron Organization for Advanced Research (see Chapter 5). Brief descriptions of activities and accomplishments of groups in the Section are given in the following pages.

3.1 THEORY - J. S. Faulkner

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

During the reporting period the Theory Group made significant advances in the efficiency of the programs that it uses for the first principles calculation of the electronic structure and physical properties of metallic alloys. Because of these advances we can now conduct systematic studies of alloy phases. These calculations are unique in that the only input parameters are the atomic numbers and concentrations of the constituents and the crystal structure. The calculated quantities can include the lattice parameter, the electronic structure, the electrical resistivity, the magnetic moment, and the susceptibility of the alloy to the development of short-range order.

During the reporting period we performed an extensive study of the Hume-Rothery alloys. This study provided the first rigorous understanding of Vegard's law. Our calculations on the Cu-Pd system provided a detailed explanation of the X-ray photoelectron spectrum as well as the diffuse X-ray scattering due to short-range order. We also extended our techniques for treating disordered alloys to treat the type of disorder associated with atomic vibrations.

We have pioneered an important new development in the theory of interatomic bonding. By analyzing the results of first principles calculations of the force on each atom originating from each molecular orbital, we are able to make a connection between our rigorous first principles calculations and the simple, powerful, intuitive ideas of chemical bonding.

3.2 X-RAY RESEARCH AND APPLICATION - C. J. Sparks, Jr.

The X-Ray Research and Applications Group applies X rays as a scattering probe and interprets the resulting X-ray scattering measurements to determine the atom distributions that deviate from 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 affect the physical and chemical properties and that are important to advancing practical and theoretical concepts for designing new materials.

We recently installed an X-ray facility at the National Synchrotron Light Source (NSLS). Advanced X-ray optics designed for this beam line permit us to achieve an intense and focused beam of X rays to study the weak scattering associated with defects. The use of energy selectable synchrotron radiation will allow the first systematic study of structures comprising those elements that have a similar number of electrons. Among these technologically important alloy systems are Fe with the additions of Ni, Cr, Co, Mn, V, and Ti. This facility has now achieved operational status. Our advanced X-ray optics performed well. These optics use X-ray diffracting crystals for intercepting and focusing the horizontally divergent synchrotron radiation. The sagittally focusing crystals developed here will intercept 5 times more radiation than mirrors at 10 keV, increasing to 30 times more at 40 keV. At a magnification of one and with 5 milliradians of radiation intercepted, the focusing optics imaged the fractional millimeter source width of the NSLS X-ray ring. Intensity losses were negligible for the 8- and 14-keV X rays tested, and the measured fluences matched those derived from the parameters defining the intensity from the storage ring. After a shakedown period to define the operational parameters for accurate energy calibration, focusing, and beam intensity measurements, the beam line will be open later this fall to other scientists at university and industrial laboratories for collaborative research.

X-ray diffraction measurements of nonrandom distribution of elements among various coordination sites have produced 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. For example, work on the $\text{Cr}_{23-x}\text{Fe}_x\text{C}_6$ tau carbide system was completed with a study of a crystal of composition $\text{Cr}_{22.26}\text{Fe}_{0.74}\text{C}_6$. Results revealed that substitution of iron for chromium on the four metal-atom symmetry sites of the cubic tau carbide structure was far from random. They show that iron solubility in Cr_2C_6 was limited when significant numbers of iron atoms were forced into sites bonded to carbon. Despite the low iron content, analyses of a large precise set of both Mo K α data and edge-tuned synchrotron radiation diffraction data yielded order parameters whose differences from random had statistical significance. The detection of iron at such low concentrations and with the small difference in X-ray scattering amplitude implies a possible sensitivity to the detection of vacancies at concentrations down to 1 in 3000 atoms.

We have made major progress in refining our theoretical interpretation of diffuse scattering data with the help of Dr. Lawrence Shaffer of Anderson College, Indiana, who is spending a sabbatical with us. The Debye-Waller factor is correctly included in the expression, and higher order displacement terms are added with their appropriate anomalous dispersion terms. This will allow us to more completely unravel the chemical order and interatomic distances between atom pairs in many alloy systems.

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.

This year two new fully equipped analytical electron microscopes (AEMs) were put into operation: a 200-kV JEM2000FX and a 300-kV Philips EM430T, each operating with LaB₆ filaments. The improvements in performance for penetration, imaging, and microanalysis expected at 300 kV compared with more conventional 100-kV operation were confirmed. Work continued on effects limiting microanalysis - secondary fluorescence and partial ionization cross-section calculations. Work began on site occupation determination of ternary additions to L1₂ alloys such as Ni₃Al by electron channeling microanalysis. The measurement of chemical segregation profiles by AEM continued with Monte Carlo calculations of beam spreading, optimization of AEM operation for 2-nm spatial resolution, and experimental measurements being made. The degree of equilibrium grain boundary segregation of antimony in a model stainless steel was correlated to boundary character. In the future, we will use combined AEM-atom probe studies for other grain boundary structure-segregation correlations.

As we await delivery (expected late 1985) of an atom probe field ion microscope (APFIM), the fast timing electronics, a video and video-digitizing system, and software programs for interactive control of the APFIM and data analysis were completed. Computer-simulated FIM images and imaging atom probe images of segregation at boundaries and multiphase alloys were made and will help establish optimum operating modes. Experimental APFIM work was performed at the Universities of Pittsburgh and Oxford (UK). A comparison between APFIM, TEM, and SANS measurements of characteristic distances in an isotropic spinodally decomposed Fe-Cr-Co alloy demonstrated good agreement. A combined APFIM-AEM study of aged cast primary coolant pipe steel revealed the formation of G-phase particles and spinodal decomposition of the ferrite matrix, which probably are responsible for the degradation of fracture properties in these duplex (~20% ferrite) steels after low-temperature aging.

A major emphasis of the group again involved collaborative applications. Work on ion-implanted ceramics centered on microstructures developed during post-implantation annealing of Al₂O₃ implanted with iron or stoichiometric quantities of aluminum and oxygen ions. In Ni₃Al-based alloys, segregation, phase identification, APB anisotropy, and the disordering process were studied by AEM in support of the ordered intermetallic

alloy development effort. Collaborative research on structural ceramics involved characterization of sol-gel-derived powders for ZTA, phase identification in exudants and the role of oxygen in liquid phase sintering of TiB_2 ceramics, and low-temperature CVD SiC-coated microspheres.

Group members were also involved in about ten collaborative research projects of the SHaRE program including creep deformation and the role of boron in SiC, catalyst-support interactions, grain boundary segregation in alumina, segregation in supercooled alloys, and deformation of Ni_3Al .

3.4 STRUCTURE AND PROPERTIES OF SURFACES AND INTERFACES - C. J. McHargue

This group was formed in late 1984 to bring together activities concerned with the characteristics of the near-surface region of solids or the interfaces between dissimilar solids. Two principal lines of research are being followed: ion beam modification of ceramic surfaces and the properties of thin films deposited on various substrates. Work in the group is supported by Basic Energy Sciences, Energy Conservation and Utilization Technologies, Fossil Energy Advanced Research and Technology Development, internal exploratory studies, and the Air Force Office of Scientific Research.

The regrowth of the amorphous states produced in Al_2O_3 and SiC by ion implantation has been studied by Rutherford backscattering-channeling (RBS-C), transmission electron microscopy, Raman spectroscopy, electron channeling, and mechanical property changes. The softening of Al_2O_3 due to amorphization was confirmed by measurements with the recently installed ultra-low-load hardness test apparatus. Two stages of regrowth were identified for Al_2O_3 . Below 1200°C , regrowth of the amorphous phase gives a columnar substructure whose c-axis coincides with the c-axis of the substrate. Once formed, this substructure is reasonably stable to further thermal treatments. Above 1200°C , epitaxial regrowth occurs rapidly with the recrystallized crystal being indistinguishable from the substrate.

Recovery in highly damaged but crystalline α -SiC begins at temperatures as low as 200°C . The annealing of the disorder as measured by RBS-C is completed within 10 min at 1000°C . The amorphous phase, however,

is quite stable. A small amount of recovery was observed to occur at the amorphous-crystalline interface in the temperature range of 200 to 1400°C. Rapid regrowth begins at 1500°C.

The ion beam modification task will now address a study of the mechanism of formation of the amorphous state, further studies on surface mechanical properties, and the reactivity of ion-implanted SiC.

The first stage of design and construction of a dynamic resonance device for thin-film mechanical property measurements has been completed, and sensitivity and stability criteria for 100- to 1000-Å film property measurements have been demonstrated. Preliminary measurements have been made for 500- and 1000-Å gold films on sapphire, 100-Å chromium on sapphire, and 1000-Å nickel on sapphire. The results at room temperature quantitatively demonstrate that gold films do not bond to sapphire sufficiently to support stress in flexural deformation of a film-and-substrate composite. Chromium and nickel do, however, and, for the nickel films, elastic property measurements have been made from room temperature to 500°C. The measurements show the elastic constants varying smoothly from bulk polycrystalline nickel values at room temperature to approximately one-third of those for bulk nickel at 500°C. These measurements illustrate an apparent softening of the film at elevated temperatures that cannot be rationalized on the basis of bulk nickel behavior. A strong dissipative process at the nickel-sapphire interface is thus indicated, and this point is being pursued with both theoretical and experimental testing.

3.5 PHYSICAL PROPERTIES - D. L. McElroy

Our research seeks an understanding of energy transport phenomena acting in materials of interest to specific programs. Our property measurements are analyzed in terms of scattering mechanisms that control charge and heat transport. We find this a useful approach in guiding further research.

About 30% of our effort was for the Office of Basic Energy Sciences in support of the alloy design and structural ceramics programs. Transport measurements on Ni₃Al containing 24 and 25 at. % aluminum were extended to 1000 K, and the results showed that phonon conduction and the Sommerfeld

Lorenz number can adequately account for the relationship observed between the electrical and thermal conductivities. These results also show that the temperature variations resemble those of an alloy, and this is probably due to the scattering associated with the loss of ferromagnetic order at lower temperatures. The thermal expansion characteristics of this compound are not sensitive to stoichiometry. The thermal and electrical conductivities of a high-purity, polycrystalline TiB_2 sample were determined over the temperature range 80 to 400 K. The thermal conductivity reached a maximum value of about 135 W/m·K at 140 K, and this maximum appears to be due to the electronic thermal conductivity component. Assuming that the electronic component behaves like $\alpha\text{-Ti}$ and adjusting for the increased lattice stiffness of the boride yields an estimate that about two-thirds of the measured thermal conductivity is electronic. Theoretical calculations of the phonon contribution satisfactorily account for the remaining third. The thermal conductivity of this high-purity sample was also found to be about 60% greater than some previously reported values. Electrical resistivity measurements were also obtained up to 1800 K. These results do not show any unusual behavior and can be described by the Bloch-Grüneisen equation as modified to account for the effect of thermal expansion on the lattice stiffness.

The Office of Building Energy Research and Development provides support for two projects in this group. One is to establish reliable property data for insulating and building materials that is needed to ensure their proper use to conserve energy in buildings; the other is to explore ways to improve the thermal resistance of insulations for appliances. The building materials project involves subcontracted work at other national laboratories, universities, and private companies as well as use of capacity at ORNL. The ORNL flat insulation tester uses a self-guarding nichrome screen wire heater with computer to obtain steady-state and non-steady-state data on panels, batts, and boards. Low-density insulations show radiation as a dominant heat transfer mechanism, but heat capacity data and radiative properties are needed for current theoretical analyses. Our study of the extent of settling of common loose-fill attic insulations after installation showed large variability in both thickness and density, which implies a range of thermal resistance values in a given attic. Our

participation in the building community technical societies allows these results and those of subcontracted research to be used. Our study to improve appliance insulations included theoretical analyses and measurements on fine-powder systems. R-values per inch near 7 were measured for pure fumed silica powders in air, and powder in panels initially evacuated to 0.01 MPa (0.1 atm) gave values near 16 three years after fabrication. R-values per inch in excess of 40 were observed for mixtures of fine and coarse amorphous silica powders under vacuum.

Our capacity to measure properties was used on a variety of materials for projects supported by the U.S. Department of Energy. These projects seek primary knowledge of the influence on material properties of structure, composition, processing, and temperature. Specific examples of this were evident in tests on current-voltage behavior of ZnO-base varistors, properties of U_3Si and U_3Si_2-Al cermets, Cr_2O_3 alloys of Al_2O_3 , heat engine insulators, the thermal conductivity of fibrous alumina and carbon-bonded carbon fibers from 400 to 1200 K in gases, thermal expansion anisotropy in epoxy fiberglass specimens, and increased emittance of 304 stainless steel by oxidation in wet argon as compared with air oxidation. We summarized the physical property literature for six alloys for the Toroidal Fusion Core Experiment.

3.6 DEFECT MECHANISMS - L. K. Mansur

Activities in the Defect Mechanisms Group center on three areas: an extensive basic program in radiation effects on materials; development of new tools for work in defect studies of materials, including ion beam treatment and surface analysis facilities; and plasma-materials interaction studies relevant to fusion reactor applications. A hallmark of the group's efforts is that both theory and experiment are combined to attack major problem areas. Interactions with other researchers include continuing collaborations with Division groups developing materials for fusion and fission reactor applications and working in electron microscopy. Numerous interactions with outside investigators in universities and industry are maintained.

Theory

Theoretical research covers original developments in the theory of radiation effects and defect behavior as well as modeling to support the experimental program. We have made several advances during the report period. Our construction of the overall framework of cascade diffusion theory is now complete. In this work, the discrete production of point defects in cascades is introduced. Earlier work using models based on rate theory homogenizes point defect production. The new theory has led to the discovery of an important mechanism of irradiation creep - cascade-induced creep - and is now being applied to other effects. A comprehensive microstructural model incorporating the simultaneous evolution of dislocation structure and cavities, together with gas production and the presence of precipitates, is being compared with experimental observations for a large array of stainless steel swelling data. We have developed several calculational codes that incorporate features of many of the currently quantified processes operating during irradiation. They serve as a resource for rapidly examining conditions of interest in planned experiments, for example. In the areas described below, the theoretical program parallels the experimental program.

Microstructural Evolution

The purposes of this work are to characterize microstructural changes produced by irradiation and to understand the mechanisms responsible by means of critical experiments. Comparative ion irradiations of Fe-35 Ni-15 Cr and Fe-15 Ni-15 Cr have been completed. Preliminary analysis revealed the remarkable result that the critical cavity radius for bias-driven swelling is at least an order of magnitude larger for the high-nickel alloy. These experiments were designed and interpreted on the basis of theory. The large difference in critical radii is now understood as the cause of the well-known difference in swelling behavior between high-nickel and low-nickel ternaries (the low-nickel ones swell much more readily) that has been sought by researchers for over a decade. We have recently begun both neutron and ion irradiations of ceramics. The initial experiments are of a scoping nature covering MgC, Al_2O_3 , and MgAl_2O_4 .

irradiated in the Fast Flux Test Facility and in the Oak Ridge Research Reactor, and MgO irradiated with O^{++} ions. A series of beam pulsing experiments using a new very-high-frequency pulser has been completed. Pulsing leads to large differences compared with steady irradiations in a phase-unstable 316 type stainless steel. Preliminary results for a swelling-resistant titanium-modified 316 type stainless steel show a trend in the microstructures of increasing similarity to steady irradiations for higher pulsing frequencies.

Phase Instability

Research in this area emphasizes the mechanisms of phase changes and interactions with microstructural evolution during irradiation, as well as the connection between properties such as swelling and phase instability. A series of 28 simple alloys based on Fe-15 Ni-13 Cr-X, where X denotes one or more minor alloying additions, has been a main topic of research. Extensive aging treatments and ion irradiations have been completed and the microstructure characterized. Alloys of special interest are those where irradiation triggered precipitation of a fine dispersion of phosphide precipitates. The very high precipitate-matrix interfacial area traps gas and, by nucleating many cavities, ensures that the critical number of gas atoms for rapid cavity swelling is not acquired in any cavity. Alloys developed employing this principle are among the most swelling-resistant alloys available.

Embrittlement

The objective of this work is to understand the mechanisms by which microstructural evolution and phase changes lead to changes in mechanical properties. The work pursues several complementary approaches. The assignment of one of our scientists to the KFA-Jülich, Federal Republic of Germany, has been completed. The collaborative research took advantage of the Jülich capability for cyclotron injection of helium. The work was carried out in nickel-silicon alloys, where silicon segregation is pronounced, in experiments designed to help separate helium embrittlement from solute-segregation embrittlement. Specimens so treated are being fractured and analyzed on our Auger system, followed by analytical transmission

electron microscopy. A series of more complex neutron-irradiated austenitic and ferritic alloys have been fractured and analyzed in similar fashion. To isolate the effects of helium alone from those of irradiation (e.g., segregation or hardening), we are developing a glow-discharge tritium-trick apparatus. Here ^3H is diffused into the specimen and decays by β^- emission, to effectively implant ^3He into the specimen. The introduction of a glow discharge into this process promises to increase greatly the helium levels attainable and thus make pure helium-embrittlement studies possible in these materials.

Accelerator Improvements

A main research facility is our 5-MV/400-kV dual ion accelerator system. Developments in research capabilities for ion beam treatment and ion beam microanalysis are pursued so that advanced techniques may be applied to an increasing range of materials problems. In the recent past we have applied the accelerators to ion beam mixing, ion implantation, and ion beam microanalysis by nuclear reactions. Planning is under way for procurement of a new accelerator. This machine, at 2.5 MV, will have energy intermediate between our existing Van de Graaffs.

The new machine will open up two main research areas. The first is to enable simultaneous triple beam irradiations (or quadruple irradiations when the 0.4-MV machine is used to accelerate hydrogen and helium simultaneously). This capability is deemed essential for ceramics work. Both the cation and the anion (e.g., Mg and O or Al and O) will be directed onto the specimen by using the two larger accelerators. Thus, both the effects of radiation damage and the defect behavior resulting from stoichiometric changes can be investigated. The second area is a major improvement in capabilities for ion beam microanalysis; the intermediate-energy machine is ideal for a variety of nuclear near-surface probe techniques.

Plasma-Material Interactions

The purposes of this research are to characterize and understand how material-plasma interface phenomena affect plasma quality and hydrogen recycle behavior, and to develop methods to improve fusion reactor plasmas

and first walls. This research has shifted strongly toward the use of dense hydrogen-containing carbon films for impurity control and improved plasma behavior. This use of dense carbon films formed in situ for impurity control in experimental fusion devices is an outgrowth of previous collaborative studies at ORNL, the KFA in Jülich, Federal Republic of Germany, and the JET tokamak in Culham, England. These films are now used routinely in the TEXTOR and JET tokamaks with considerable success. Much remains to be learned, however, about the deposition and use of these films for fusion applications. Because of the high hydrogen content and high recycling from the films, a critical issue for reactor use and even for several of today's devices is tritium retention and handling, or simply the control of the isotopic composition of the plasma in contact with the film. We are studying the structure, composition, redeposition, and hydrogen recycle characteristics of films made under controlled laboratory conditions in order to relate the structure, hydrogen content, and hydrogen recycle characteristics to the deposition parameters.

In our studies of hydrogen recycling from wall materials, it is desirable to extend the range of parameters accessible in our plasma-wall interactions simulator. A new chamber 150 mm (6 in.) in diameter has been built to permit study of a wider range of incident hydrogen fluxes (presently $\sim 10^{17} \text{ cm}^{-2} \text{ sec}^{-1}$) down to $10^{14} \text{ cm}^{-2} \text{ sec}^{-1}$. The wide range of fluxes should help in differentiating the various mechanisms important in recycling.

3.7 STRUCTURAL MATERIALS DEVELOPMENT - 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 (ADIP) Program funded by the Office of Fusion Energy. This program is primarily concerned with the development of materials to withstand the temperatures, stresses, chemical environment, and neutron damage levels expected in power-producing fusion reactors, which are several generations away from current experimental fusion

devices. The recent United States decision not to proceed with a near-term large tokamak machine has led to a redirection of the ADIP Program. For first-wall and blanket applications, a two-stage materials development program is envisaged. During the next decade, the primary objective will be to demonstrate the ability of a variety of alloys to successfully sustain damage levels of the order of 100 displacements per atom (dpa) coupled with the high concentrations of helium (1000-1500 at. ppm) generated by (n, α) reactions. These materials should possess low-activation characteristics to simplify the waste disposal problems associated with power-producing reactors. In addition, compatibility with a variety of possible coolants and breeder materials must be demonstrated. For other reactor components, the radiation damage resistance of a variety of ceramic materials and high-strength copper alloys must also be demonstrated. For the second stage of the program, a powerful source of 14-MeV neutrons will be required to establish the performance of advanced materials at damage levels beyond 100 dpa. Such a machine will generate, in all materials, the gaseous and solid transmutants characteristic of those produced in a (D,T)-burning fusion machine.

The first stage of the program requires extensive use of both the Fast Flux Test Facility (FFTF) at Hanford and the High Flux Isotope Reactor (HFIR) at ORNL. Engineering Technology and Operations Divisions personnel have begun work to improve the irradiation facilities at the HFIR to provide the capability of (1) temperature measurement and control and (2) shielding of experiments to alter the local neutron spectrum (spectral tailoring). Three major techniques have been established or are being established to permit control of the generation rate of helium in all materials during reactor irradiations. They are:

1. Spectral tailoring, which will be used in the HFIR to control the helium:dpa ratio in nickel-containing alloys and also to control the rate of transmutation of copper in copper alloys. This technique has been successfully demonstrated in the Oak Ridge Research Reactor (ORR).
2. Isotopic tailoring, which involves preparing alloys with their isotopic mixture adjusted to control the rate of helium production from

thermal neutron captures. For austenitic stainless steels the proportion of ^{60}Ni is increased at the expense of ^{58}Ni (which has a high thermal neutron cross section) in order to reduce the helium production rate in the HFIR. Conversely, alloys that normally contain little or no nickel are doped with up to 1.5 wt % ^{58}Ni to stimulate helium production in the HFIR. They are irradiated side by side with control samples doped with ^{60}Ni ; these metallurgically identical alloys will produce virtually no helium. The metallurgical effects of adding small concentrations of nickel to 9 and 12 Cr ferritic steels have been established over the past several years in a series of experiments both in and out of reactor.

3. Tritium decay, a technique in which tritium is diffused into the material in a controlled manner and allowed to decay to ^3He . This allows uniform concentrations of helium to be introduced before irradiations in a hard neutron spectrum such as that of the FFTF. So far it has been successfully demonstrated for vanadium alloys.

We plan to use all three techniques in an irradiation program utilizing both the HFIR and the FFTF in order to explore the response to helium generation and displacement damage of a wide range of materials including vanadium alloys, copper alloys, and ferritic and austenitic stainless steels.

During the past year, work on the austenitic stainless steels has been concentrated on the joint United States-Japanese collaborative program on irradiations in the HFIR and the ORR. A series of eight capsules, with space equally shared between the United States and Japan, were inserted on schedule into the HFIR. These experiments will establish the performance of a titanium-modified steel (PCA) at damage levels of 50 dpa and with very high concentrations of helium (~2500 at. ppm). Developmental versions of PCA microstructurally designed for improved strength, phase stability, and an ability to trap helium on a fine scale are also included in these experiments. Because of their improved strength, these alloys are being investigated for possible applications for advanced steam cycle superheaters in a collaborative program with the Mechanical Properties Group. The successful demonstration of microstructurally based methods of controlling helium damage will be of major benefit to ongoing

alloy development efforts to develop reduced activation versions of austenitic stainless steels. The initial phase of this work involves an investigation of austenite stability in steels containing 10 to 16% chromium, 0.1 to 0.2% carbon, and with manganese substituted for nickel to improve activation characteristics.

A second important achievement in the United States-Japanese collaborative program was the insertion of two spectrally tailored capsules in the ORR. In these capsules the He:dpa ratio for austenitic steels is similar to that produced in a fusion machine. These experiments provide data on austenitic stainless steels that is crucial to the Japanese design efforts on their next-generation tokamak machine (FER). A notable feature of one of the capsules is the ability to achieve for the first time irradiation temperatures in the range 60 to 200°C. A joint Magnetic Fusion Energy-Basic Energy Sciences experiment is contained in this capsule to explore irradiation creep phenomena in a range of materials.

Work on vanadium alloys focused on the mechanical properties of alloys irradiated in the EBR-II and in the FFTF. The effects of helium were studied by diffusing controlled quantities of tritium into unirradiated alloys and allowing the tritium to decay to ^3He ("tritium trick"). The latter experiments demonstrated widely varying effects of helium on ductility, depending on alloy composition and microstructure. The neutron irradiation results showed that even in the absence of helium very low ductilities occur in the reference V-15 Cr-5 Ti alloy after irradiation in the range 400 to 500°C. Loss of ductility in this range is accompanied by a change to a cleavage fracture mode; the possibility of contamination by interstitial elements in these experiments has been eliminated. Further work is in progress to investigate this phenomenon and to extend the irradiation data base on helium-doped alloys to about 45 dpa.

To explore the effects of helium on the bainitic and martensitic stainless steels, we are studying the feasibility of doping these alloys with up to 2 wt % nickel in order to utilize the (n,α) reactions with ^{58}Ni and ^{59}Ni in the HFIR. The metallurgical effects of nickel on the aging, tensile, and Charpy impact properties are now well understood and can be accounted for in assessing the effects of helium on mechanical behavior. So far tensile and Charpy impact data obtained on nickel-doped 9 Cr and

12 Cr steels show that helium levels up to 150 at. ppm have no effect on properties for irradiation temperatures in the range 400 to 600°C. Helium levels of 300 to 400 at. ppm strongly enhance void nucleation in these materials; data on void growth rate will become available during FY 1986.

Our initial approach to developing low-activation ferritic materials involves substituting tungsten and vanadium for molybdenum and niobium in steels with chromium contents ranging from 2 1/4 to 12 wt %. The tempering behavior and tensile properties of these alloys are similar to those of the conventional steels. The general prospects for developing ferritic materials with reduced activation characteristics are so far very encouraging.

In support of the SP-100 Space Nuclear program, a unique facility was installed in the Bldg. 3025 hot cells to allow tensile testing of refractory metals and alloys at temperatures up to 1350°C in a vacuum of 10^{-8} torr. An important candidate structural alloy, Nb-1 Zr-0.1 C, was tested after an irradiation conducted in EBR-II by Hanford Engineering Development Laboratory at temperatures ranging from 1200 to 1300°C. The results demonstrated that no loss of ductility would occur in this alloy as the result of end-of-life neutron exposures.

During the past year, the group's experimental capabilities were further extended by the construction of a facility in Bldg. 4501 for mechanical testing of tritium-bearing materials. In the Bldg. 3025 hot cells, installation was completed of a scanning electron microscope, a Charpy impact machine for miniaturized specimens in collaboration with the Pressure Vessel Technology group, and a second high-temperature, high-vacuum neutron machine. Substantial progress was made on the installation of a precision densitometer and a second MTS fatigue machine.

3.8 FUELS QUALIFICATION - M. J. Kania

A Fuel Materials Qualification Program is being conducted for the Gas-Cooled Reactor (GCR) Program in cooperation with GA Technologies (GA). The irradiation testing of GA-fabricated coated-particle fuel is performed in the High Flux Isotope Reactor in capsules designed and assembled at ORNL. Extensive post-irradiation examination (PIE) of the fuels is

conducted at the High Radiation Level Examination Laboratory with special facilities and equipment developed for this purpose.

The past year's principal activity related to fuels irradiation has been the preparation and assembly of Capsules HRB-17 and HRB-18. These experiments are designed to evaluate the performance of failed GCR fuel when it is subjected to moisture levels simulating various water ingress events. The scheduled insertion date of the irradiation capsules is August 1985.

The level of effort on PIE has been relatively low because the backlog of irradiated fuels is minimal and because extensive upgrading and modification of PIE equipment has been undertaken. Included in this latter activity were the replacement of the automated particle handler device of the Irradiated-Microsphere Gamma Analyzer (IMGA), upgrading of the computer control and data acquisition system for IMGA, qualification of the Post-Irradiation Gas Analyzer, and upgrading and maintenance of the X-radiography facility and shielded electron microprobe.

In addition to the cooperation with GA, the CRNL fuels program includes specific cooperative tasks with the German Nuclear Research Center (Kernforschungsanlage) at Jülich. The GCR fuels work with Kernforschungsanlage-Jülich is part of the formal agreement between the United States and West Germany on GCR development.

3.9 LABORATORY TECHNIQUES AND SUPPORT FACILITIES - 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 past two years. Being nonconductors, ceramics cannot be thinned to electron transparency by electrolytic thinning as can metal samples. New techniques were developed for sample preparation by use of mechanical erosion for prethinning followed by ion milling to electron transparency. 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 in cross sections were developed.

An improved process for electrolytic extraction of precipitates from bulk metal samples has been perfected, and a new technique was developed for preparing fine powder samples for TEM. With the acquisition of an atom probe by the Division, techniques have been developed successfully to produce needle-sharp specimens for this instrument, where the radius of the hemispherical end is 0.01 to 0.1 μm .

4. PROGRAM ACTIVITIES

This section of the report deals with the various program 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, Liquid Metal Reactor Materials, Conservation Technology, Fossil Energy Materials, Fusion Energy Materials, Gas-Cooled Reactor Materials, Graphite Activities, Heavy-Section Steel Technology, Space Nuclear Projects, Special Nuclear Projects, and the Steel Initiative.

4.1 BASIC ENERGY SCIENCES-MATERIALS SCIENCES - J. O. Stiegler

The Basic Energy Sciences-Materials Sciences Program is aimed at providing an understanding of the behavior of materials in terms of processes occurring at the atomic level. During the past year, the program has been reorganized slightly to focus on three topics concerned with development of principles for the design of advanced materials. High-temperature alloys based on intermetallic compounds, structural ceramics, and radiation-resistant materials are being investigated. A new effort on Structure and Properties of Surfaces and Interfaces has been established by merging our Surface Modification and Surface Studies Programs. We are taking steps to integrate our Welding Program into the broader national effort that is supported by Basic Energy Sciences in that area.

The key to our approach is our ability to specify composition and microstructure on an atomic level. We maintain strong efforts in material characterization, including electron microscopy, an imaging atom probe, and an X-ray station at the National Synchrotron Light Source. We also pursue the development of theory of alloys. The characterization and theory programs provide both support and leadership for the programs devoted to the design of advanced materials.

4.2 LIQUID METAL REACTOR MATERIALS - J. R. DiStefano

After termination of the Clinch River Breeder Reactor Plant Project, the U.S. Department of Energy (DOE) restructured its Nuclear Energy Reactor Development Program. As presently structured, the base technology program represents a significant departure from the previous line of development. Emphasis is now being placed on the supporting research and development required for the near-term, advanced, innovative Liquid Metal Reactor (LMR) concepts and on those foreign exchange activities that give the United States access to European and Japanese developments.

As a result of these revised DOE objectives and a nationally reduced budget, the LMR Materials Program at ORNL now consists of four major activities: (1) mechanical properties, (2) the Nuclear Systems Materials Handbook (NSMH), (3) nondestructive testing, and (4) advanced alloy development. Except for nondestructive testing, tasks generally focus on activities required to bring modified 9 Cr-1 Mo steel to a state of commercialization for use in the advanced nuclear systems. During FY 1984-85 a key accomplishment was securing *ASME Boiler and Pressure Vessel Code* approval for use of the modified 9 Cr-1 Mo steel under Section VIII (Pressure Vessels) rules. In addition a data package was submitted to Section III (Nuclear Power Plant Components) and actions initiated for Code Case N-47 approval. Other high priority tasks focus on removing key impediments to the development of reliable, economically competitive, and licenseable LMR designs. Those tasks include filling gaps in required design data and developing techniques and methods to meet unique in-service inspection requirements in hostile environments. In the latter area a highly innovative pulsed eddy-current system has been developed that is capable of inspecting thick-section magnetic materials such as the 2 1/4 Cr-1 Mo steel being used for tubing in the Westinghouse double-wall steam generator.

Although the restructured program has placed less emphasis on materials research and development, we continue to believe that an active materials program is essential to the success of the advanced systems under consideration.

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 or major materials support tasks in the following conservation projects: (1) Energy Conversion and Utilization Technologies (ECUT) Materials, (2) Ceramic Technology for Advanced Heat Engines, (3) Building Insulation and Materials, (4) ECUT Tribology, (5) Industrial Waste Energy Recovery, and (6) Electric Energy Systems. In the first three 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 research and innovative ideas that are beyond the scope of either the applied conservation programs or basic research. The ECUT Materials Project provides the major funding for our development of the ordered intermetallic alloys and for smaller tasks involving innovative research on ceramic processing, 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.

The Ceramic Technology for Advanced Heat Engines Project was initiated in FY 1983 to meet the ceramic technology requirements of the DOE Office of Transportation Systems (OTS) 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 those engines. An assessment of needs was completed through extensive interaction with industrial ceramic and

engine companies, and a five-year project plan was developed. Research and development tasks on (1) materials and processing, (2) materials design methodology, and (3) data base and life prediction are accomplished through ORNL in-house research and through subcontracts with industry, universities, and other government laboratories. The ORNL in-house research is on development and characterization of toughened ceramics and joining of structural ceramics to metals. The construction of and equipment for the High Temperature Materials Laboratory (HTML) are being funded by OTS. The Ceramic Technology Project will provide major research funding for the HTML.

The objective of the Building Insulation and Materials 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 Energy 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 the Conservation Technology projects but at a somewhat slower rate.

4.4 FOSSIL ENERGY MATERIALS PROGRAM - R. A. Bradley

The Fossil Energy Materials Program at ORNL consists of three major activities:

1. technical support to the Oak Ridge Operations (ORO) of the U.S. Department of Energy (DOE) 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, and
3. in-house research and development on the AR&TD Fossil Energy Materials Program and the Surface Gasification Materials Program.

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 for the conversion of coal to liquid and gaseous fuels, ORNL provides technical support to 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 for the AR&TD Fossil Energy Materials Program is directed at the development of corrosion-resistant alloys and coatings with emphasis on understanding the development and breakdown of protective oxide scales, erosion- and wear-resistant alloys and cermets, high-temperature structural alloys ranging from

advanced austenitic to ordered intermetallic alloys, and structural ceramics and refractories with emphasis on the development of whisker- or fiber-reinforced ceramic composites with improved strength and toughness.

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 materials and 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 for the Surface Gasification Materials Program are similar to those for the AR&TD Fossil Energy Materials Program. In-house activities for the Surface Gasification Materials Program include tasks on the development of iron aluminides and electroslag component casting.

4.5 FUSION MATERIALS RESEARCH AND DEVELOPMENT - E. E. Bloom

Fusion materials research and development in the Metals and Ceramics Division consists of activities in three areas. The major activity is the development of structural materials for first-wall and blanket applications. There are three essential steps in this development activity: (1) develop a fundamental understanding of the response of materials to the fusion reactor environment, (2) design alloys by tailoring the microstructure and microchemistry for optimum performance in this environment, and (3) develop a data base for reactor concept studies and eventually for engineering design. The program has conducted screening studies on numerous alloy systems. Research and development is now focused on austenitic and ferritic steels and vanadium alloys. There is a strong focus on developing low-activation alloys within these alloy systems. In the past year our research on copper alloys, candidate alloys for compact high-power-density reactors and for components that sustain high heat fluxes, has increased substantially.

There are numerous applications for ceramics in fusion experiments and future fusion power reactors. Our understanding of the effects of the fusion environment, particularly radiation damage created by the fusion neutron spectrum, is rudimentary. We have recently begun work, collaborative with Los Alamos National Laboratory, to investigate radiation effects on critical mechanical and physical properties of ceramics. Initially, isotopically tailored (using $^{16}\text{O}/^{17}\text{O}$ and $^{14}\text{N}/^{15}\text{N}$ ratios to control helium and hydrogen production) Al_2O_3 and Sialon will be synthesized and irradiated in a mixed-spectrum reactor to investigate the effect of concomitant transmutation-produced gases and displacement damage on structure and properties.

The third area of research is the interaction of fusion plasmas with the first-wall materials. This research addresses the question of how material-plasma interface phenomena affect plasma quality and hydrogen recycle behavior, and the development of methods to improve the quality of fusion reactor plasmas through selection and control of the first-wall materials, coatings, etc.

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

As a result of comprehensive studies and evaluations conducted over the past year, a consensus was reached among United States Gas-Cooled Reactor (GCR) Program participants to focus current development activities on the side-by-side/steel vessel (SBS/SV) modular GCR. This, of course, has resulted in a requirement to re-assess technology needs including those for materials. Work is now proceeding, with highest priority, to define and document a materials technology development program for the SBS/SV concept. In the interim, work on materials is confined to those generic areas believed almost certain to apply to the new system.

Three classes of materials important to GCRs - fuels, graphites, and structural alloys - are being covered at ORNL. The efforts on qualification of GCR fuel are summarized in Section 3.8, Fuels Qualification. The graphite program has continued its concentration on fracture mechanics and statistics, increasingly focused on the development of failure criteria

for graphite under multiaxial stress fields. A strong program has also been under way to obtain a nuclear-quality Stackpole 2020 graphite. This has involved close cooperation with the supplier in the selection and specification of raw materials and processing techniques.

Work in the structural alloys area has continued on those materials expected to be selected for critical components of the SBS/SV GCR such as the steam generator and reactor internals. Testing in progress includes long-term and creep-rupture tests in simulated GCR helium, low-cycle fatigue and creep-fatigue interactions, high-cycle fatigue, fracture mechanics, and thermal stability. Additionally, cooperative efforts with West Germany and Switzerland are addressing low-cycle fatigue, fracture mechanics, and high-temperature failure criteria and design codes. These tasks are covered under international agreements on GCR development.

4.7 GRAPHITE PROGRAMS - W. P. Eatherly

The work in graphite and carbon technology crosses a number of other programs, the bulk of the support coming from the High Temperature Gas-Cooled Reactor Program, the Advanced Nuclear Systems Materials Program, and various activities related to space and to isotope separation technologies. The most marked shift in the past year has been away from bulk graphites and increasingly toward carbon-polymer and carbon-carbon composite materials.

The activities on bulk graphite have continued to concentrate on the statistical character of graphite and fracture mechanics, but currently with a strong focus on providing a mechanistic base for a multi-axial stress failure criterion. The statistical problem has become quite complex in that bulk graphite exhibits a bimodal flaw system. The background flaws are describable by Weibull statistics and the disparate flaws by a volume-sensitive statistic currently being handled as a combination of binomial and order statistics. The fracture mechanics is further complicated by a pseudo-plastic microcracking phenomenon operating in advance of the crack tip.

The composite program has heretofore been dominated by our work with carbon-bonded carbon-fiber insulation (CBCF), for which we now have essentially a complete multicomponent theory of thermal conductivity. With the increasing demand for very-high-temperature material in space and military applications, exploratory work has been initiated in higher-temperature polymer systems, improved carbon-fiber structures, and new fabrication techniques for multidimensional lay-ups. These activities are at present only in a formative stage.

4.8 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. Additionally, ultrasonic examination of reactor vessels to determine flaw density and mechanical testing in support of viscoplastic studies are being pursued.

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 welds with relatively low Charpy upper-shelf energy, representing early commercial practice. Series 4 is similar except that the materials represent current-practice welds. All Charpy impact, tensile, and fracture toughness testing has been completed, and results are being analyzed. 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 102 mm thick are being irradiated. The irradiations began in the Oak Ridge Research Reactor in May 1984 and will be completed in April 1986. Series 7 is designed to determine the effects of irradiation

on stainless steel cladding. Phase I was completed with the testing of irradiated Charpy and tensile specimens of single-wire submerged-arc types 309 and 308 stainless steel. The results showed that good quality stainless steel weld cladding is not degraded by neutron irradiation, but poor quality cladding (high dilution) is severely degraded. The program is continuing with the irradiation of three-wire series-arc 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. Fractographic studies of structural tests and companion laboratory crack arrest specimens show no indication of conversion from cleavage to ductile tearing before arrest.

4.9 SPACE NUCLEAR PROJECTS - R. H. Cooper

Efforts continue to establish a substantial role for ORNL in the Space Nuclear Reactor Program. At present the program is funded by the Department of Defense, Department of Energy, and National Aeronautics and Space Administration and is primarily focused on the selection by FY 1985 of a viable multi-100-kW(e) reactor concept to be ground tested in 1989 and deployed by 1995. Additional funding is expected in FY 1986 for development of concepts and technologies for a multimegawatt space nuclear power system to be deployed by the year 2010.

In FY 1986 the Metals and Ceramics Division will have a lead role in the development of an engineering data base for candidate refractory alloys being considered for fuel-cladding and structural applications for multi-100-kW(e) reactor applications. Active tasks will include characterization of alloy irradiation effects; determination of the creep properties of Nb-, Ta-, Mo-, and W-based alloys; and fabrication of refractory alloy mill products for important component and system testing activities.

It is highly likely that the Metals and Ceramics Division will also serve in a lead laboratory role for the development of advanced material technologies needed to support multimegawatt space nuclear concepts. These development activities will focus on the development of candidate refractory alloys, ceramics, and composite systems.

4.10 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 1987, 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 demonstration of a consumable-arc-melting, extruding, and rolling technique to produce blanks with minimal porosity; nondestructive examination support for manufacture of advanced thermoelectric elements and the blanks; 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.

4.11 STEEL INITIATIVE - V. K. Sikka

The main objective of the Steel Initiative is to develop innovative (leap-frog) technologies for the making, shaping, and treating of steel. The task on innovative methods for the making of steel and its electromagnetic continuous casting are being carried out at Argonne National Laboratory (ANL). The ORNL task deals with the "direct processing of near-net-size castings to final product." The main objective of this task

is to eliminate the hot rolling during the processing of those near-net-size castings to the final products. Additional objectives are to

1. interface with ANL's task of electromagnetic continuous casting to define the maximum thickness that can be cast without requiring hot rolling and the minimum thickness that is required to give final desired properties,
2. achieve good uniformity of properties (a highly desirable feature for the automated fabrication industry), and
3. provide a wide range of properties without the need for many compositions.

Since the start of the steel program in January 1985, ORNL efforts have concentrated on defining the minimum thickness required to give the final desired properties. To perform this task, a water-cooled copper mold with variable spacers was developed. The spacers allow the casting of slabs 1/8, 1/4, 1/2, and 1 in. in thickness. This mold was used to cast several slabs of 1/8- and 1/4-in. thickness and one each of 1/2- and 1-in. thickness. All castings have been of drawing-quality special-killed (DQSK) grade. The cast slabs were cold rolled to sheet 0.030 in. thick. The sheet quality has been excellent in all cases. The sheet was punched into tensile specimens with orientations longitudinal, transverse, and 45° to the rolling direction. Specimens were annealed for 30 min at 538, 649, 704, and 927°C. The specimens have been both fast and slow cooled from the annealing temperature. The cold-rolled and annealed specimens have been tensile tested at room temperature. Initial results suggest that 1/8-in.-thick slab castings may be adequate to obtain the desirable properties without hot rolling. However, these results are based on the very high cooling rates obtained during casting in a copper mold. We believe that electromagnetic continuous casting will permit much slower cooling rates than were used here. Thus the current work is focused on varying the cooling rates during casting. Furthermore, one hot-rolling pass may be required to obtain satisfactory internal soundness of the castings. That possibility is being investigated.

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To achieve uniformity of properties and reduce the number of compositions that provide similar properties, we plan to design and build a thermomechanical simulator/processing device. This activity will require capital equipment funding and thus will begin in FY 1986 when full funding for the steel initiative is expected.

5. COLLABORATIVE RESEARCH FACILITIES

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 three specialized facilities: High Temperature Materials Laboratory, Shared Research Equipment Program, and Oak Ridge Synchrotron Organization for Advanced Research. A brief status report on each activity is presented.

5.1 HIGH TEMPERATURE MATERIALS LABORATORY - V. J. Tennery and J. V. Cathcart

The High Temperature Materials Laboratory (HTML) is the Metals and Ceramics Division's new research and user facility. Sponsored by the Heat Engine Propulsion Division, Office of Transportation Systems, Conservation and Renewable Energy, U.S. Department of Energy, the HTML will serve as the focal point for a multidisciplinary staff investigating ceramics that show potential for high-temperature applications. Typical research projects in the initial HTML program will include the development and characterization of dispersion-toughened SiC and oxide-metal composites, ceramic-metal joining studies, development of nondestructive examination methods for advanced structural ceramics, advanced statistics of brittle fracture, and studies of tensile cyclic fatigue in structural ceramics.

The HTML will also serve as a user facility for the industrial and university research communities. More than a third of its 49 laboratories will be devoted to four User Centers: Materials Analysis, High Temperature X-Ray Diffraction, Physical Properties, and Mechanical Properties.

Our goal is to equip these centers with state-of-the-art research instruments necessary to characterize the microstructure and microchemistry of materials and to relate those parameters to the physical and mechanical properties.

The Materials Analysis and X-Ray User Centers will contain the instrumentation necessary to characterize microstructure and microchemistry and for the analysis of surface composition. The Physical Properties User Center will emphasize measurements of thermal and electrical transport properties, but dilatometric, calorimetric, and DTA/TGA instruments will also be available. The Mechanical Properties User Center will contain universal test machines, equipment for studying dynamic fatigue in both ceramics and metals, and a variety of other fracture and fatigue facilities. In this center, as in the other three, computer control of instrumentation will be emphasized in order to optimize the efficiency of user operations. A special User Center staff will be available to assist users and to maintain the equipment, but users will be expected to participate actively in collaborative research. No charge will be assessed for nonproprietary research work, but arrangements can also be made for carrying out proprietary work.

The HTML was designed by Deeter, Richey, Sippel (DRS), a Pittsburgh, Pennsylvania, architectural firm, as a two-story building providing 64,500 ft² of floor space. It will contain 49 laboratories and 72 offices for the permanent research staff, users, and other visitors. There will be a small reading room, three conference rooms, and the usual array of support areas. The modernistic architectural style of the building reflects our commitment to research at the frontiers of materials science.

Ground was broken in February 1985. The construction site is just south of Bldg. 4508 in close proximity to the rest of the Metals and Ceramics Division complex. Procurement of the special research equipment for the HTML User Centers is under way, and excellent progress is being made in the construction of the building. Completion of construction is officially scheduled for February 1987; however, there is a possibility that we may be able to take beneficial occupancy of at least a portion of

the building by late summer or early fall of 1986. Thus we anticipate that the HTML and its User Centers will be fully functional no later than July 1987 and possibly a few months earlier.

5.2 SHARED RESEARCH EQUIPMENT PROGRAM - E. A. Kenik

The SHaRE program allows participants from universities, industrial research organizations, and other national laboratories access to the unique combination of microanalytical facilities available in the Metals and Ceramics Division. 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 intermediate-voltage (300-kV) analytical electron microscope has been added, and an atom probe-field ion microscope 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-based aluminides, high-temperature ferritic alloys, and high-performance ceramics.

During this period, the Division of Materials Sciences, Office of Basic Energy Sciences, provided funds through Oak Ridge Associated Universities (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 1984 were: E. A. Kenik, ORNL; P. S. Sklad, ORNL; R. Wieseuegel, ORAU; J. J. Hren, Professor, Department of Materials Science and Engineering, University of Florida, Gainesville; and R. F. Davis, Professor, North Carolina State University, Raleigh.

One change was made in the FY 1985 steering committee: C. B. Carter, Cornell University, replaced J. J. Hren.

During this reporting period, 20 SHaRE projects were active, involving about 46 participants. Some 15 papers based on SHaRE research were published, and about 25 presentations were made at technical meetings.

5.3 OAK RIDGE SYNCHROTRON ORGANIZATION FOR ADVANCED RESEARCH - C. J. Sparks, Jr.

A synchrotron radiation beam line installed by the Oak Ridge National Laboratory at the National Synchrotron Light Source (NSLS) at Brookhaven is made available to interested users from university and industrial laboratories through a contract administered by Oak Ridge Associated Universities. University staff and industrial scientists are invited to join in collaborative research in materials science of importance to DOE programs at a large and unique research facility not available at their home institutions. More than 20 institutions are presently members. The beam line will supply focused X-radiation spanning the energy spectrum from 3 to 40 keV at energy resolutions of $\delta E/E = 2 \times 10^{-4}$. One Oak Ridge Associated University staff member is stationed at the NSLS to interface with the users and to develop computer programs for data acquisition and analysis. Among the research capabilities available on this beam line are: crystallography on small samples; structure of amorphous materials both liquid and solid; diffuse X-ray scattering from crystalline defects, short-range order, and atomic displacements; and X-ray spectroscopy of electron rearrangements.

The beam line has achieved operational status now that the X-ray ring is operational. Tests of the advanced X-ray optics designed at the Oak Ridge National Laboratory proved them to be functional and to have met our design criteria. The sagittally focusing crystals developed here will intercept 5 times more radiation than mirrors at 10 keV, increasing to 30 times more at 40 keV. At a magnification of one and with 5 milliradians of radiation intercepted, the focusing optics imaged the fractional-millimeter source width of the NSLS X-ray ring. Intensity losses were negligible for the 8- and 14-keV X rays tested, and the

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measured fluences matched those derived from the parameters defining the intensity from the storage ring. After a shakedown period to define the operational parameters for accurate energy calibration, focusing, and beam intensity measurements, the beam line will be open later this fall to other scientists at university and industrial laboratories for collaborative research.

Appendix A

BUDGET AND FINANCIAL CHANGES

For the 12 months ending June 30, 1985, expenditures for in-house activity in the Metals and Ceramics Division for ongoing R&D efforts decreased 4.2%, with a projected decrease of 3.4% through September 1985. In FY 1985, funding for Conservation and HTGR increased considerably while funding for Basic Energy Sciences, Fusion Energy, and Space Reactors remained constant. Large losses were suffered in Flight Systems Support, Waste Management, and LMFBR. Overall, funding remained fairly constant from FY 1984 to FY 1985 for DOE programs because of increases in Conservation and HTGR that offset losses in Flight System Support, Waste Management, and LMFBR. However, funding for Work for Others programs experienced a 12.2% decrease during the 12 months ending June 30, 1985, with an 18% decrease projected through September. The total projected decrease is 2.2%. Figure A.1 illustrates total change in funding for DOE and Work for Others programs.

Fig. A.1. In-house activity for the U.S. Department of Energy and Work for Others.

The level of subcontracting, which is represented primarily by two projects (Conservation and Fossil Energy), is projected to be \$6,357,000 through September 1985. This is a slight increase over FY 1984 as shown in Table A.1.

Table A.1. Division budget
(Thousands of dollars)

Fiscal year	Operating funds	Subcontracting funds
1984	27,289	6245
1985	26,691 ^a	6357 ^a

^aEstimates.

Basic Energy Sciences continues to be the largest program, with Conservation, which is rapidly growing, as second. Major programs as percentages of total budget (excluding subcontracting) are listed in Table A.2.

Table A.2. Percentage of total funding by major program

Program	Percentage
Basic Energy Sciences	26
Conservation	22
Fusion Energy	10
Fossil Energy	8
Nuclear Regulatory Commission	8
HTGR	6
Advanced Energy Systems	6
All other programs	14
Total	100

Appendix B

PERSONNEL CHANGES

July 1, 1984, to June 30, 1985

New Staff Members

A. Scientific Staff

D. R. Johnson (transferred from K-25, Process Support)
V. J. Tennery (transferred from Central Management Offices)

B. Administrative and Technical Staff

A. H. Knaff, Administrative Support
D. D. McCoy, Administrative Support

Staff Transfers and Terminations

A. Scientific Staff

G. M. Adamson (retirement)
R. G. Berggren (retirement)
B. S. Borie (retirement)
W. H. Butler (transferred to Central Management Offices)
G. W. Clark (retirement)
G. L. Copeland (transferred to Y-12)
D. P. Edmonds (voluntary resignation)
M. K. Ferber (voluntary resignation)
C. B. Finch (transferred to Solid State Division)
R. J. Gray (retirement)
J. P. Hammond (retirement)
W. J. Lackey (voluntary resignation)
A. P. Maclin (completion of temporary assignment)
J. C. Ogle (retirement)
P. Patriarca (retirement)
S. F. Peterson (retirement)
G. W. Scott (transferred to Martin Marietta Aerospace)
H. L. Yakel (retirement)

B. Administrative and Technical Staff

L. M. Beeler (transferred to Engineering Division)
 M. S. Booker (transferred to Personnel Division)
 J. B. Flynn (retirement)
 J. T. Houston (retirement)
 M. R. Manning (retirement)
 B. J. McNabb, Jr. (retirement)
 D. R. Underwood (transferred to Chemical Technology Division)
 J. J. Woodhouse (retirement)

Guest Assignments

A. Scientific Staff

Yaw-Chung Cheng, Energy & Mining Research/Service Organization,
 Taiwan, Republic of China
 S. Hamada, Japan Atomic Energy Research Institute, Tokai-mura, Japan
 D. J. Han, International Atomic Energy Agency, Vienna, Austria
 G. L. Lehman, Oak Ridge Associated Universities, Oak Ridge, Tennessee
 D. M. Nicholson, University of Tennessee, Knoxville, Tennessee
 K. V. Rao, Cabot Corporation, Kokomo, Indiana
 M. P. Tanaka, Japan Atomic Energy Research Institute, Tokai-mura,
 Japan
 H. M. Tawancy, Cabot Corporation, Kokomo, Indiana

B. ORAU Postdoctoral Research Fellowship Program

G. C. Farlow, University of North Carolina, Chapel Hill,
 North Carolina
 A. Habenschuss, Iowa State University, Ames, Iowa
 F. A. List, III, Cornell University, Ithaca, New York

C. Co-op Assignments

J. R. Dendy, Georgia Institute of Technology, Atlanta, Georgia
 D. M. Dillard, Georgia Institute of Technology, Atlanta, Georgia
 J. A. Hanigofsky, University of Akron, Akron, Ohio
 E. S. Hotchkiss, Georgia Institute of Technology, Atlanta, Georgia
 A. M. Hougland, Virginia Polytechnic Institute and State
 University, Blacksburg, Virginia
 M. T. Kehne, Georgia Institute of Technology, Atlanta, Georgia

Summer Assignments (1984 and 1985)

A. Scientific Staff

R. G. Faulkner, Loughborough University of Technology,
 Leicestershire, England
 G. Kirkiadidis, University of Salford, England

B. Administrative Staff

D. L. Carter, University of Tennessee, Knoxville, Tennessee
R. L. Durchsprung, Maryville College, Maryville, Tennessee
S. M. Hancher, University of Tennessee, Knoxville, Tennessee
T. G. Harmon, Tennessee Technological University, Cookeville,
Tennessee
C. L. Horner, University of Tennessee, Knoxville, Tennessee

C. Technical Support Staff

J. Cesarano, III, University of Washington, Seattle, Washington
F. T. Greenwald, University of Illinois, Urbana, Illinois
V. S. Inouye, Washington University, St. Louis, Missouri
J. A. Stefani, Columbia University, New York, New York
S. G. Zorko, Ohio State University, Columbus, Ohio

D. ORAU-University Faculty

F. W. Kutzler, Tennessee Technological University, Cookeville,
Tennessee
T. A. Nguyen, Massachusetts Institute of Technology, Cambridge,
Massachusetts
F. J. Pinski, University of Cincinnati, Cincinnati, Ohio

E. ORAU-Undergraduate Research Trainees

M. C. Maguire, Colorado School of Mines, Golden, Colorado
P. Lipetzky, Montana State University, Bozeman, Montana
J. C. Pawel, University of Tennessee, Knoxville, Tennessee

Appendix C

ORGANIZATIONAL STRUCTURE AND CHART

During the report period, the Division continued to operate with personnel deployed in a matrix organizational structure. The regular line organization consisted of three research and development sections containing 21 functional groups and an administrative support staff. The other arm of the matrix structure consisted of ten management offices that administer and maintain oversight responsibility for the programmatic effort. An organizational chart of the Division as of July 1, 1985, is included in this appendix.

Shortly after the start of the fiscal year, J. O. Stiegler assumed the directorship of the Division from J. R. Weir, Jr., who became associate director. To accommodate this change, former associate director J. E. Cunningham was placed on special assignment until he retires.

Several other changes in personnel assignment were made during the report period:

- V. J. Tennery was named head of the Processing Science and Technology Section and continued to manage the High Temperature Materials Laboratory, which earlier had been folded into the structure of the Metals and Ceramics Division.
- J. O. Stiegler replaced C. J. McHargue as manager of the Basic Energy Sciences Program.
- J. R. DiStefano replaced P. Patriarca as manager of the Breeder Reactor Materials Program.
- E. E. Bloom replaced J. L. Scott as manager of the Fusion Energy Materials Program.

Other changes that occurred during the report period included the following:

The Processing Science and Technology Section was renamed the High Temperature Materials Section.

The Metals Processing Group moved to the Engineering Materials Section.

The Surface and Solid Reactions functional group was dissolved. A new Structure and Properties of Surfaces Interfaces Group headed by C. J. McHargue was formed.

The Metallography functional group moved to the High Temperature Materials Section.

A new Fuels Qualifications Group under the leadership of M. J. Kania was formed in the Materials Science Section.

The Welding and Brazing Group was renamed the Materials Joining Group.

The name of the Publications Office was changed to Publications, Communications, and Records Support Services.

V. J. Tennery was named acting leader of the Coatings and Tribology Group.

Appendix D

HONORS AND AWARDS

The Metals and Ceramics Division at Oak Ridge National Laboratory has established a long-standing tradition of excellence. The quality of its research and the success of its development work have been the result of established ability of its scientific and engineering staff. Since the Division's initial achievements, this ability has been formally recognized in the many professional honors received.

Presented below is a listing of special honors and awards accorded to Divisional staff personnel during the report period. 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, appointments, patents issued, conference involvement, professional society involvement, and commendations.

HONORIFIC AWARDS

P. F. Becher was named an honoree in the publications category at the 1985 Energy Systems Awards Night ceremonies and cited for superior employee performance in the authorship of the technical article entitled "Mechanical Reliability of Ceramic Windows in High Frequency Microwave Heating Devices."

A. Bleier was named contributing Editor of Communications in Ceramic Processing, in the *Journal of the American Ceramic Society*, in December 1984.

S. A. David was elected a Fellow of the American Society for Metals.

R. J. Gray received the 1984 American Society for Metals Albert Sauveur Achievement Award.

J. P. Hammond was recognized and cited "for sustained creativity in the fabrication of nuclear reactor fuels and development of methods for joining refractory metals and ceramics for energy applications" in the inventions category at the 1985 Energy Systems Awards Night ceremonies.

H. Inouye was named a recipient in the inventions category at the 1985 Energy Systems Awards Night ceremonies and cited "for development of temperature and impact-resistant precious metal alloys as cladding materials for radioisotope thermoelectric generators to power space probes to the outer planets."

D. M. Kroeger, J. O. Scarbrough, and C. G. McKamey were named honorees in the publications category at the 1985 Energy Systems Awards Night ceremonies and cited for superior employee performance in the authorship of the technical article entitled "Effects of Short-Range Order on Electronic Properties of Zr-Ni Glasses as Seen from Low-Temperature Specific Heat."

R. J. Lauf was named an honoree in the publications category at the 1985 Energy Systems Awards Night ceremonies and recognized for superior employee performance in the authorship of the technical article entitled "Out-of-Reactor Studies of Fission Product-Silicon Carbide Interactions in HTGR Fuel Particles."

C. T. Liu received a Distinguished Alumni Award from Brown University (Graduate School) at the 1985 Commencement Ceremonies for his distinguished contributions to national well-being by professional achievement.

C. T. Liu was elected a Fellow of the American Society for Metals.

C. T. Liu was named "Scientist of the Year" and cited "for exemplary contributions in the field of ordered intermetallic alloys, resulting in the development of nickel aluminides that maintain structural integrity at high temperatures" in the technical achievement category at the 1985 Energy Systems Awards Night ceremonies.

C. T. Liu was honored and presented a silver Jefferson Cup at the Honors Night Award ceremonies of Martin Marietta Corporation for superior achievement and excellence in materials research. He was recognized and

cited "for numerous contributions to the science and technology of inter-metallic alloys, the most notable being solution of the long-standing brittleness problem of nickel-aluminide alloys, resulting in a family of new super alloys having superior high-temperature properties."

C. T. Liu, C. L. White, and J. A. Horton were winners in the U.S. Department of Energy's 1984 Materials Sciences Research Competition in Metallurgy and Ceramics: Significant Implication for Energy Technology category for their entry "Design of Ductile Nickel Aluminides for High Temperature Structural Use."

L. K. Mansur was named a recipient in the technical achievement category at the 1985 Energy Systems Awards Night ceremonies and cited "for leadership in theoretical modeling and experimentation, resulting in a comprehensive understanding of the evolution of microstructure in metals and alloys during neutron irradiation."

B. J. McNabb, Jr., was cited "for outstanding service in technical support to materials science and technology" in the operational performance category at the 1985 Energy Systems Awards Night ceremonies.

D. P. Stinton, with E. W. McDaniel and H. O. Weeren of the Chemical Technology Division, (authors) and Irene Brogden (editor) won the Award of Excellence in the Scholarly and Professional Articles category in the Society for Technical Communication, East Tennessee Chapter, 1985 Competition, and the Award of Achievement in the same category at the International Technical Publications competition in Houston, Texas, for the article entitled "Characterization of Hydrofracture Grouts for Radionuclide Migration."

R. W. Swindeman was selected by the American Society for Testing and Materials as a recipient of the Award of Merit and Fellowship in the Society.

T. N. Tiegs was cited "for contributions to the development of SiC whisker reinforced ceramic composites" in the technical achievement category at the 1985 Energy Systems Awards Night ceremonies.

EXHIBITION PRIZES

S. A. David, J. C. Griess, and C. W. Houck (with **J. L. Rich**, Information Division) won second place in the 1984 International Metallographic Exhibit for their poster on "Solidification Substructure for Titanium Alloys Now Revealed by Potentiostatic Etching."

J. J. McGowan has been selected as the Exhibit Chairman for the American Society of Mechanical Engineers' Pressure Vessel and Piping Division Conferences for 1986, 1987, and 1988.

P. S. Sklad, P. Angelini, and J. T. Houston won first place in the Analytical Electron Microscopy Class at the International Metallographic Exhibit for a poster entitled "Analytical Electron Microscopy of Ion Implanted Silicon Carbide."

D. P. Stinton and J. C. McLaughlin won first place in the 1985 Ceramographic Exhibition at the American Ceramic Society Annual Meeting for their poster entitled "Toughened Ceramic Composites Can be Produced by Simultaneous Chemical Vapor Deposition of Two Phases."

ELECTED OFFICERS AND MEMBERS

A. Bleier was inducted into the membership ranks of Sigma Xi of the National Scientific Research Society in November 1984.

W. R. Corwin was elected Chairman of the Oak Ridge Chapter of the American Society for Metals.

L. L. Horton was elected to serve as Council Secretary of the Electron Microscopy Society of America for the four-year term 1985-89.

J. R. Keiser was elected Vice-Chairman of Committee T-2F of the National Association of Corrosion Engineers for the 1985-87 term.

T. S. Lundy was elected to be an Advisory Member of the Board of Direction of the Building Thermal Envelope Coordinating Council.

D. L. McElroy was elected to serve a second term as Chairman of the Governing Board of the International Thermal Conductivity Conference and will serve through the end of CY 1985.

J. J. McGowan was elected Vice Chairman of the Materials and Fabrication Committee of the American Society of Mechanical Engineers for 1984-85.

J. L. Scott was elected to the American Nuclear Society's Materials Science and Technology Division Executive Committee for the period 1985-88.

APPOINTMENTS

S. A. David was appointed a member of the National Materials Advisory Board Committee on Welding Controls.

M. L. Grossbeck was appointed Chairman of the Program Committee of the Materials Science and Technology Division of the American Nuclear Society for the 1985-86 term.

E. A. Kenik was appointed to the Education Committee of the Electron Microscopy Society of America.

E. A. Kenik was appointed the Electron Microscopy Society of America's representative to the American Association for the Advancement of Science.

R. L. Klueh was appointed to the *Metal Progress* Editorial Committee of the American Society for Metals for the 1985-88 term.

C. T. Liu was appointed to the Materials Research Society's Awards Committee for a three-year term (1985-87).

C. T. Liu was appointed as a member of the Awards Nomination and Long-Range Planning Committee of the Materials Research Society.

T. S. Lundy was appointed to the National Executive Committee of the National Institute of Building Sciences to fill an unexpired term and then elected by the membership to a full three-year term starting in 1985.

R. W. McClung was appointed Chairman of the Honor Lecture Subcommittee of the American Society for Nondestructive Testing Awards Committee.

D. L. McElroy was appointed Chairman of the C16.30 Committee on Thermal Measurements of the American Society for Testing and Materials.

J. J. McGowan was appointed to Subcommittee 2 on Materials Properties in Design of the ASME Materials and Fabrication Committee for 1984-85.

R. K. Nanstad was appointed Vice-Chairman of the Fabrication Division of the Pressure Vessel Research Committee.

R. E. Pawel was appointed as a member of the TMI-2 Debris Examination Review Group, EG&G, Idaho, Inc.

A. F. Rowcliffe was appointed Chairman of the U.S. Department of Energy's Office of Fusion Energy Task Group on Alloy Development for Irradiation Performance.

P. S. Sklad was appointed to the 1985 Program Committee of the Electron Microscopy Society of America to organize a Symposium on electron microscopy of surface modified materials.

P. S. Sklad was appointed Vice Chairman of the Education Committee of the Electron Microscopy Society of America.

J. H. Smith was appointed regional representative for the southeastern United States by the American Society for Nondestructive Testing.

J. H. Smith was appointed a member of the 1986 WATtec Executive Committee.

C. J. Sparks, Jr., was appointed a member of the Advanced Photon Source Steering Committee of the U.S. Department of Energy.

D. W. Yarbrough was appointed Chairman of the C16.21 Committee on Reflective Insulation of the American Society for Testing and Materials.

PATENTS ISSUED

P. Angelini, A. J. Caputo, D. P. Stinton, R. E. Hutchens, and W. J. Lackey, "Method for Forming Microspheres for Encapsulation of Nuclear Waste," U.S. Patent 4,481,134, Nov. 6, 1984.

P. Angelini, C. E. DeVore, W. J. Lackey, and D. P. Stinton, "Method of Deposition of Silicon Carbide Layers on Substrates and Product," U.S. Patent 4,459,338, July 10, 1984.

S. A. David and J. J. Woodhouse, "Assembly for Testing Weldability of Sheet Metal," U.S. Patent 4,449,758, Feb. 19, 1985.

R. J. Lauf, "Process for Fabricating ZnO-Based Varistors," U.S. Patent 4,510,112, April 9, 1985.

G. C. Wei, "Method for Forming Fibrous Silicon Carbide Insulating Material," U.S. Patent 4,481,179, Nov. 6, 1984.

CONFERENCE INVOLVEMENT

J. Bentley served as Session Chairman for Energy Dispersive Spectroscopy Theory and Applications at the 4th Analytical Electron Microscopy Workshop and 19th Annual Microbeam Analysis Society Meeting, Lehigh University, July 16-20, 1984.

J. Bentley served as Session Chairman for the Analytical Electron Microscopy's 42nd Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, Aug. 13-17, 1984.

A. Bleier was named Chairman for organizing the session on Colloidal Interactions and Phenomena presented at the 16th Annual Meeting of the Fine Particles Society held in Miami Beach, Florida, in April 1985.

A. Bleier served as Chairman of the Ceramic Processing-I session of the 37th Pacific Coast Regional Meeting of the American Ceramic Society held in San Francisco, California, in October 1984.

A. Bleier presented an invited lecture at the Gordon Conference in June 1985.

L. L. Horton served as organizer and Session Chairman of the American Society for Metals Oak Ridge Chapter Symposium on "Composite Materials for Structural Applications."

L. L. Horton served as Session Chairman at the 12th International Symposium on the Effects of Radiation on Materials, sponsored by the American Society for Testing and Materials, Williamsburg, Virginia, June 18-20, 1984.

T. S. Lundy served on the organizing committee for the Workshop on Research in Moisture Control in Buildings, Washington, D.C., Sept. 25-26, 1984.

T. S. Lundy organized the session "Energy Efficiency in Buildings" for the American Association for the Advancement of Science Annual Meeting, Los Angeles, California, May 29, 1985.

D. L. McElroy was co-chairman of a Workshop on High Temperature Thermophysical Properties of Nuclear Oxide Fuels at the 9th European Conference on Thermophysical Properties, UMIST, Manchester, U.K., Sept. 17-21, 1984.

D. L. McElroy was Session Chairman of the Materials Session of the ASTM Conference on Thermal Insulation, Materials and Systems held in Dallas, Texas, Dec. 2-6, 1984.

N. H. Packan served on the Symposium Committee for organizing the 12th International Symposium on the Effects of Radiation on Materials, sponsored by the American Society for Testing and Materials, Williamsburg, Virginia, June 18-20, 1984.

C. J. Sparks, Jr., organized a session on Advanced Synchrotron Radiation Research for the Thirteenth Congress of the International Union of Crystallography, Homburg, Germany, August 1984.

D. W. Yarbrough served as organizer and Session Chairman, 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, Philadelphia, Pennsylvania, Aug. 20-23, 1984.

PROFESSIONAL SOCIETY INVOLVEMENT

E. E. Bloom continues to serve on the Metals Engineering Institute Committee of the American Society for Metals for the 1984-86 term.

K. V. Cook continues as Chairman of the Subgroup on Pipe and Testing Inspection of the American Society for Testing and Materials.

J. E. Cunningham continues to serve as immediate past Chairman of the Honors and Awards Committee and as a member of the Book Publishing Committee of the American Nuclear Society.

C. V. Dodd continues as a member of the Editorial Advisory Board for the *International Journal of Nondestructive Testing*.

M. M. Martin will serve as a member of the membership committee of the American Society for Metals for the 1985-87 term.

R. W. McClung continues as Chairman of Subcommittee E7.10 of the American Society for Testing and Materials.

C. J. McHargue continues to serve on the International Metals Review Committee of the American Society for Metals for the 1984-86 term.

P. Patriarca continues to serve on the Academy for Metals and Materials Committee of the American Society for Metals for the 1983-85 term.

G. M. Slaughter continues on the Board of Trustees of the American Society for Metals for the 1984-86 term.

J. H. Smith continues as Director of the American Society for Nondestructive Testing.

J. R. Weir, Jr., continues to serve on the Government and Public Affairs Committee of the American Society for Metals for the 1983-85 term.

COMMENDATIONS

C. R. Brinkman received a Certificate of Appreciation from the Board of Governors of the American Society of Mechanical Engineers for his services to the Society and its Boiler and Pressure Vessel Committee.

W. R. Corwin received a Certificate of Appreciation from the American Society for Testing and Materials for chairing a symposium held in 1983.

S. A. David received an ORNL pin in recognition of his leadership and help in the American Welding Technology Application Center recruitment effort.

R. W. Swindeman received a Certificate of Appreciation from the Pressure Vessels and Piping Division of the American Society of Mechanical Engineers in recognition of his service as Chairman of the Materials and Fabrication Committee from 1982 to 1984.

Appendix E

SEMINAR PROGRAM

Because effective exchange of information is so vital to scientific and technological advance, the Division sponsors and maintains an active seminar program for communication of ideas and discussion of results among researchers working in the broad field of material science and engineering. Most of the talks deal with technical topics and are presented by invited speakers affiliated with research institutions located elsewhere in North America and abroad. The actual number of talks scheduled in any given week varies but, over the year, averages more than one per week.

The seminar program is administered by a committee appointed by Division management. The 1984-1985 Seminar Committee consisted of J. A. Carpenter (chairman), J. P. Hammond, P. S. Sklad, and J. A. Horton.

It is interesting to note that 39 of the 69 talks in 1984-1985 were made by individuals affiliated with institutions located outside the United States. An alternate breakdown shows 46 talks by university faculty members and graduate students, 8 by representatives from industrial firms, and the balance from governmental and other research institutions.

In function, the program achieves the desired goal of providing a forum for free exchange of information and for the passage of intellectual ideas that one can criticize, react to, and act upon. In short, these periodic exchanges aid the researcher in his or her quest for new knowledge and provide stimuli for further meaningful work that enhances basic understanding. The speakers and topics of seminars presented in the past year are listed below:

F. Thümmel, University of Karlsruhe, Federal Republic of Germany,
"Ceramics at the University of Karlsruhe," July 9, 1984.

L. Martinez, University of Mexico, Mexico City, "An Experimental Study of the Evolution of Creep Cavity Size Distributions," July 11, 1984.

H. J. Pollock, University of Lancaster, Lancaster, England, "Characterization of Ultra-Thin Layers Using Continuous Depth Recording: Theory and Applications," July 12, 1984.

M. N. Roilos, University of Patras, Patras, Greece, "Conduction Mechanisms of Transition Metal Oxide Glasses," July 13, 1984.

S. W. Freiman, National Bureau of Standards, Gaithersburg, Maryland, "Environmentally Enhanced Crack Growth in Glasses and Ceramics," July 13, 1984.

T. Moisio, University of Technology, Lappeenranta, Finland, "Plasma Arc Welding," July 16, 1984.

L. Martinez, University of Mexico, Mexico City, "On the Measurement of Surface Free Energies of Solids," July 16, 1984.

G. H. Meier, University of Pittsburgh, Pennsylvania, "High-Temperature Corrosion of SiO_2 -Forming Alloys," July 17, 1984.

J. J. Eberhardt, U.S. Dept. of Energy, Washington, D.C., "The Mission of the ECUT Program and Its Plans for Materials by Design," July 18, 1984.

P. C. Euthymiou, University of Athens, Athens, Greece, "Transport in III-V Semiconductors and MESFETs," August 6, 1984.

A. W. Nicholls, University of Birmingham, Birmingham, England, "The Application of Analytical Electron Microscopy to Segregation Studies," August 9, 1984.

W. A. Coghlan, Arizona State University, Tempe, Arizona, "Low Dose Swelling Experiments on MgAl_2O_4 at Los Alamos," August 10, 1984.

P. Townsend, University of Sussex, England, "Ion Implantation in Insulators," August 17, 1984.

R. G. Faulkner, Loughborough University of Technology, Leicestershire, United Kingdom, "Thermally Induced Grain Boundary Segregation in Steels," August 21, 1984.

R. L. Mills, Ohio State University, Columbus, "Fractal Wave Functions in Disordered Systems," August 22, 1984.

T. L. Anderson, The Welding Institute, Cambridge, England, "Assessing the Dominant Mechanism for Size Effects in the Ductile-to-Brittle Transition Region," August 23, 1984.

R. G. Faulkner, Loughborough University of Technology, Leicestershire, United Kingdom, "Effects of Irradiation on Segregation in Ferritic Steels," August 28, 1984.

F. J. Pinski, University of Cincinnati, Ohio, "Electronic Structure of $\text{Fe}_{1-x}\text{Ni}_x$ Alloys: Implications for the Invar Effect," August 30, 1984.

R. G. Faulkner, Loughborough University of Technology, Leicestershire, United Kingdom, "Quantitative Microanalysis in STEM," August 30, 1984.

I. Aksay, University of Washington, Seattle, "Processing of Ceramic Matrix Systems by Colloidal Techniques," September 10, 1984.

Y. Shida, Sumitomo Metal Ind., Japan, "Influence of Particle Properties on Solid Particle Erosion of Stainless Steel at High Temperatures," September 25, 1984.

P. C. Clapp, University of Connecticut, Storrs, "Martensitic Nucleation in a Computer," September 26, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "High-Temperature Corrosion of Nickel in SO_2 and $\text{SO}_2 + \text{O}_2$," October 2, 1984.

R. S. Jupp, Michigan Technological University, Houghton, "Grain Boundary Structure in Alpha Aluminum Oxide," October 8, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "High-Temperature Corrosion of Nickel Alloys (Ni-20 Cr and dilute Ni-Mn) in $\text{SO}_2 + \text{O}_2$," October 9, 1984.

T. C. Reiley, T. J. Watson Research Center, Yorktown Heights, New York, "High Dielectric Constant Material Compatible with Low Firing Electronic Ceramics," October 11, 1984.

M. Kikuchi, Tokyo Institute of Technology, Tokyo, Japan, "Nitrogen in Austenitic Stainless Steels," October 12, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "Hot Corrosion of Nickel," October 15, 1984.

T. L. Lin, Shanghai Jiao Tong University, Shanghai, China, "The Effect of Stress and Temperature on the Extent of Primary Creep in Directionally Solidified Nickel-Base Superalloys," October 23, 1984.

M. R. Hayns, Safety and Reliability Directorate, United Kingdom Atomic Energy Authority, Warrington, United Kingdom, "Quantitative Risk Analysis for Nuclear and Non-Nuclear Hazards - A U.K. View," October 24, 1984.

V. P. Kujanpaa, University of Oulu, Oulu, Finland, "Solidification and Weld Defects in Austenitic Stainless Steels," November 1, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "High-Temperature Oxidation of Chromium and Properties of Chromia Scales," November 6, 1984.

M. Labranché, Massachusetts Institute of Technology, Cambridge, "Oxidation of Chromium in H_2 - H_2O - H_2S Gas Mixtures," November 12, 1984.

H. M. Tawancy, Cabot Corp., Kokomo, Indiana, "Ordering Behavior and Properties of Ni-Mo Alloys," November 15, 1984.

D. A. Papaconstantopoulos, U.S. Naval Research Laboratory, Washington, D.C., "Exploring Possibilities for High-Temperature Superconductivity in Nitrides and Hydrides," November 15, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "High-Temperature Corrosion of Iron in CO + CO₂," November 20, 1984.

J. Stohr, Office National D'Etudes et de Recherches Aerospatiales, Chatillion-Sous-Bagneux, France, "Intermetallic Alloys and Rapid Solidification," December 3, 1984.

P. Kofstad, University of Oslo, Oslo, Norway, "Hydrogen Defects in Y₂O₃," December 4, 1984.

S. M. Hsu, National Bureau of Standards, Gaithersburg, Maryland, "The NBS Ceramic Initiative," December 10, 1984.

W. Schilling, Institut für Festkörperforschung, KFA Jülich, West Germany, "Helium in Metals," December 10, 1984.

T. Y. Tien, University of Michigan, Ann Arbor, "Development of Transformation-Toughened Al₂O₃-Cr₂O₃," December 12, 1984.

H. D. Brody, University of Pittsburgh, Pennsylvania, "Models of Solidification Processes," December 13, 1984.

J. I. Nurminen, Westinghouse Research and Development Center, Pittsburgh, Pennsylvania, "Laser Processing of Materials," December 14, 1984.

A. Howie, University of Cambridge, England, "Energy-Loss Mechanisms Studied by Scanning Transmission Electron Microscopy," January 14, 1985.

W. Madder, Max Planck Institute, Stuttgart, West Germany, "High-Resolution Electron Microscopy of Diffusion-Bonded Nb-Al₂O₃ Interfaces," January 24, 1985.

Y. Kobayashi, Mitsubishi Motors Corporation, Tokyo, Japan, "Development of a Ceramic Rotor and Other Ceramic Components for an Automotive Gas Turbine," March 1, 1985.

G. L. Messing, Pennsylvania State University, University Park, "Transformation and Sintering of Seeded Boehmite (AlOOH) Sol Gels," March 4, 1985.

S. P. Hannula, Cornell University, Ithaca, New York, "The Use of Indentation Techniques in the Evaluation of Mechanical Properties of Small Material Volumes," March 25, 1985.

L. C. Wadsworth, University of Tennessee at Knoxville, and C. B. Hassenboehler, U.S. Department of Agriculture, Knoxville, Tennessee, "Melt-Blown and Spunbonded Composites for Energy Conservation," March 23, 1985.

A. Nyce, Goram International, Goram, Maine, "High-Pressure-Activated Sintering and Sinter/Hipping of Ceramics," April 8, 1985.

P. Eklund, University of Kentucky, Lexington, "Resonant Interband Raman Scattering in Metals and Semimetals," April 18, 1985.

S. J. Zinkle, University of Wisconsin, Madison, "Effect of Thermal Annealing and Ion Irradiation on the Properties and Microstructures of Copper Alloys," April 18, 1985.

J. W. Cahn, Center for Materials Science, National Bureau of Standards, Washington, D.C., "Coherent Phase Equilibria," April 19, 1985.

R. Lynn, University of Cincinnati, Ohio, "High-Temperature Sulfidation of Nickel and High-Temperature Corrosion Research at the University of Cincinnati," April 25, 1985.

J. R. Matthews, AERE, Harwell, England, "Microstructural Evolution and Irradiation Creep Modeling," April 26, 1985.

W. Bunk, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.v. (DFVLR), Cologne, West Germany, "Results of SSN and HIP SN Experiments at DFVLR Materials Laboratory, Cologne," April 29, 1985.

W. Kley, Joint Research Center, Ispra, Italy, "The JRC-ISPRA Fusion Reactor Materials Test and Development Facility," May 3, 1985.

D. Stöver, Institute for Reactor Development, KFA-Jülich, West Germany, "Research on Oxidation-Sulfidation and Pre-Oxidation at KFA-IRE," May 6, 1985.

R. Sinclair, Stanford University, Stanford, California, "High-Resolution Electron Microscopy of Semiconductor Interfaces," May 9, 1985.

H. Knoch and D. Steinmann, Elektroschmelzwerk Kempten GmbH, Munich, West Germany, "The Sintering of Carbide and Boride Ceramics," May 10, 1985.

D. Carruthers, Garrett Turbine Engine Company, Phoenix, Arizona, "AGT 101 Status and Materials Needs," May 14, 1985.

W. Boldmann, Consultant, Geneva, Switzerland, five days of lectures on "Crystal Lattice and Interfaces," May 22-26, 1985.

C. C. Koch, North Carolina State University, Raleigh, "Structure of Amorphous Alloys Synthesized by Mechanical Alloying-Non-Glass-Forming Systems," May 30, 1985.

P. E. A. Turchi, University of California, Berkeley, "Electronic Structure and Phase Stability of Transition Metal Alloys: Competition Between Crystalline Effects and Configurational Order Effects," June 5, 1985.

J. Hillairet, Centre d'Etudes Nucléaires de Grenoble, Grenoble, France, "Short-Range Ordering Kinetics in Concentrated Crystalline Alloys and Metallic Glasses," June 13, 1985.

B. McEnaney and T. Burshell, The University of Bath, Bath, England, "Acoustic Emission from Graphite," June 24, 1985.

T. A. Nguyen, Massachusetts Institute of Technology, Cambridge, "Defect Structures in Highly Nonstoichiometric Materials," June 28, 1985.

Appendix F

ADVISORY COMMITTEE

The next Advisory Committee Review will occur early in 1986. An overview of the general health and welfare of the Division will be presented, as well as reports of technical progress, changes in programmatic thrust and directions, and new initiatives.

The Advisory Committee to the Metals and Ceramics Division currently consists of six members appointed by the Laboratory Director. Members are appointed for staggered terms so that two new members replace two retiring members each year. The main function of the Committee is to review ongoing research and development activities, examine the physical facilities and equipment, and render an independent judgement 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 on the basis of demonstrated ability in materials research and technology. The members of the 1985 Metals and Ceramics Division Advisory Committee are:

Dr. James C. Williams
(Committee Chairman)
Dean of Engineering
Carnegie-Mellon University
Schenley Park
Pittsburgh, Pennsylvania 15213

Dr. Harry E. Cook
Director, Automotive Research
and Technical Planning
Chrysler Corporation
P.O. Box 857
Detroit, Michigan 48288

Dr. Richard J. Charles
Research & Development Center
General Electric Company
P.O. Box 8
Schenectady, New York 12301

Professor Alan Lawley
Department of Materials Engineering
Drexel University
Philadelphia, Pennsylvania 19104

Dr. Gilbert Y. Chin
Head, Physical Metallurgy & Ceramics
Research & Development Department
Bell Telephone Laboratories
Murray Hill, New Jersey 07974

Professor William D. Nix
Department of Materials Science
and Engineering
Stanford University
Stanford, California 94305

Appendix G

PUBLICATIONS

Compiled by Faye Roseberry

W. S. Alter, R. A. Parr, M. H. Johnston, and J. P. Strizak, *High-Pressure Hydrogen Testing of Single Crystal Superalloys for Advanced Rocket Engine Turbopump Turbine Blades*, NASA TM-86464, National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Ala., August 1984.

P. Angelini, P. F. Becher, J. Bentley, C. B. Finch, and P. S. Sklad, "Processing and Microstructural Characterization of TiB_2Al Liquid Phase Sintered with Ni and Ni_3Al ," pp. 299-305 in *Defect Properties and Processing of High-Technology Nonmetallic Materials*, proceedings of symposium held in Boston on Nov. 14-18, 1983, ed. J. H. Crawford, Jr., Y. Chen, and W. A. Sibley, Materials Research Society Symposia Proceedings, vol. 24, Elsevier, New York, 1984.

P. Angelini and J. Bentley, "Secondary Fluorescence Effects on X-Ray Microanalysis," pp. 582-83 in *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

G. B. Armen, T. Åberg, K. R. Karim, J. C. Levin, B. Craseman, G. S. Brown, M. H. Chen, and G. E. Ice, "Threshold Double Photoexcitation of Argon with Synchrotron Radiation," *Phys. Rev. Lett.* 54(3), 182-85 (January 1985).

V. B. Baylor, J. R. Keiser, and D. P. Edmonds, "Considerations in Welding for Corrosive Coal Liquefaction Service," *Mater. Perform.* 22(3), 26-33 (March 1983).

V. B. Baylor and J. F. Newsome, *Laboratory Stress Corrosion Cracking Studies in Polythionic Acid*, ORNL/TM-9116, August 1984.

P. F. Becher, "Processing of Transformation Toughened Al_2O_3 - $ZrO_2(Y_2O_3)$ Composites," pp. 9-10 in *Ceramics: Science of Processing*, U.S. DOE Basic Energy Sciences Bulletin, Materials and Molecular Research Division, Lawrence Berkeley Laboratory, University of California, Berkeley, August 1984.

P. F. Becher, "Strength Degradation in SiC and Si₃N₄ Ceramics by Exposure to Coal Slags at High Temperatures," *J. Mater. Sci.* 19, 2805-14 (1984).

P. F. Becher and M. K. Ferber, "Mechanical Reliability of Ceramic Windows in High Frequency Microwave Heating Devices, Part 2, Mechanical Behaviour of the Ceramics," *J. Mater. Sci.* 19, 3778-85 (1984).

P. F. Becher and G. C. Wei, "Toughening Behavior in SiC-Whisker-Reinforced Alumina," *J. Am. Ceram. Soc.* 67(12), C-267-69 (December 1984).

P. F. Becher and G. C. Wei, "Transformation Toughened and Whisker Reinforced Ceramics," pp. 201-5 in *Proceedings of the 21st Automotive Technology Development Contractors' Coordination Meeting, November 14-17, 1983*, held in Dearborn, Mich., P-138, Society of Automotive Engineers, Warrendale, Pa., 1983.

R. L. Berger, D. P. Stinton, and E. W. McDaniel, "Selective Absorption of Radionuclides by Major Phases of Hydrofracture Grout," *Bull. Am. Ceram. Soc.* 63(3), 511 (1984).

E. E. Bloom, R. W. Conn, J. W. Davis, R. E. Gold, R. Little, K. R. Schultz, D. L. Smith, and F. W. Wiffen, "Low Activation Materials for Fusion Applications," *J. Nucl. Mater.* 122&123, 17-26 (1984).

K. W. Boling, *Design and Fabrication of a Unique Electromechanical Machine for Long-Term Fatigue Testing*, ORNL-6115, December 1984.

R. A. Bradley and P. T. Carlson, *Advanced Research and Technology Development Fossil Energy Materials Program Plan for Fiscal Years 1983 Through 1987*, ORNL/TM-8737, July 1984.

R. A. Bradley and P. T. Carlson, *Advanced Research and Technology Development Fossil Energy Materials Program Implementation Plan for Fiscal Years 1984 Through 1988*, ORNL/TM-8954, October 1984.

R. A. Bradley and P. T. Carlson, *Advanced Research and Technology Development Fossil Energy Materials Program Implementation Plan for Fiscal Years 1985 Through 1989*, ORNL/TM-9328, February 1985.

R. A. Bradley, comp., *AR&TD Fossil Energy Materials Program Quarterly Progress Report for Period Ending June 30, 1984*, ORNL/FMP-84/3, August 1984.

R. A. Bradley, comp., *AR&TD Fossil Energy Materials Program Quarterly Progress Report for Period Ending September 30, 1984*, ORNL/FMP-84/4, November 1984.

R. A. Bradley, comp., *AR&TD Fossil Energy Materials Program Quarterly Progress Report for Period Ending December 31, 1984*, ORNL/FMP-85/1, February 1985.

R. A. Bradley, comp., *AR&TD Fossil Energy Materials Program Quarterly Progress Report for Period Ending March 31, 1985*, ORNL/FMP-85/2, May 1985.

R. A. Bradley, comp., *Surface Gasification Materials Program Semiannual Progress Report for Period Ending September 30, 1984*, ORNL/SGMP-84/2, December 1984.

R. A. Bradley, comp., *Surface Gasification Materials Program Semiannual Progress Report for Period Ending March 31, 1985*, ORNL/SGMP-85/1, June 1985.

A. D. Brailsford and L. K. Mansur, *Time Dependent Rate Theory for Diffusional Defect Processes*, ORNL-G122, January 1985.

D. N. Braski, "Microstructure and Bend Ductility of a (Fe,Ni)₃V Ordered Alloy Irradiated in HFIR," *J. Nucl. Mater.* 122&123, 676-81 (1984).

D. N. Braski and J. T. Houston, "Improved TEM Specimen Holder for Semiautomatic Jet-Polishing," p. 606 in *Proceedings of Thirty-Seventh Annual Meeting Electron Microscopy Society of America, San Antonio, Texas, Aug. 13-17, 1979*, ed. G. W. Bailey, Claitor's Publishing Division, Baton Rouge, La., 1979.

D. N. Braski and P. J. Maziasz, "Tensile Properties of Unirradiated PCA from Room Temperature to 700°C," *J. Nucl. Mater.* 122&123, 338-42 (1984).

S. S. Brenner, P. P. Camus, M. K. Miller, and W. A. Soffa, "Phase Separation and Coarsening in Fe-Cr-Co Alloys," *Acta Metall.* 32(8), 1217-27 (1984).

W. H. Butler, "Resistivity of Alloys," pp. 215-30 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

W. H. Butler, "Theory of Electronic Transport in Random Alloys: Korringa-Kohn-Rostoker Coherent-Potential Approximation," *Phys. Rev. B* 31(6), 3260-77 (March 1985).

P. P. Camus, W. A. Soffa, S. S. Brenner, and M. K. Miller, "Quantification of Interconnected Microstructures by FIM," pp. C9-265-68 in *31st International Field Emission Symposium, Paris, France, July 16-20, 1984*, ed. P. Sudraud and P. Ballongue, Tome 45, Colloque C9, supplement au n° 12, *Journal de Physique*, Les Ulis Cedex, France, Décembre 1984.

A. J. Caputo and W. J. Lackey, *Fabrication of Fiber-Reinforced Ceramic Composites by Chemical Vapor Infiltration*, ORNL/TM-9235, October 1984.

A. J. Caputo and W. J. Lackey, "Fabrication of Fiber-Reinforced Ceramic Composites by Chemical Vapor Infiltration," pp. 654-67 in *Proceedings of the 8th Annual Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, Florida, January 15-18, 1984*, ed. W. J. Smothers, The American Ceramic Society, Inc., Columbus, Ohio, 1984.

A. J. Caputo, W. J. Lackey, and I. G. Wright, "Chemical Vapor Deposition of Erosion-Resistant TiB_2 Coatings," pp. 782-99 in *Proceedings of the Ninth International Conference on Chemical Vapor Deposition 1984* held in Cincinnati on May 7-10, 1984, ed. McD. Robinson, G. W. Cullen, C. H. J. van den Brekel, and J. M. Blocher, Jr., proc. vol. 84-6, The Electrochemical Society, Inc., Pennington, N.J., 1984.

Li Chang, A. Cerezo, G. D. W. Smith, M. K. Miller, M. G. Burke, S. S. Brenner, K. A. Taylor, T. Abe, and G. B. Olson, "Ageing of Fe-Ni-C Martensite," pp. C9-409-16 in *51st International Field Emission Symposium, Paris, France, July 16-20, 1984*, ed. P. Sudraud and P. Ballongue, Tome 45, Colloque C9, supplement au n° 12, *Journal de Physique*, Les Ulis Cedex, France, Décembre 1984.

I-W. Chen and M. H. Yoo, "Creep Cavitation Under Interfacial Segregation," *Acta Metall.* 32(9), 1499-1508 (1984).

O. K. Chopra and P. F. Tortorelli, "Compatibility of Materials for Use in Liquid-Metal Blankets of Fusion Reactors," *J. Nucl. Mater.* 122&123, 1201-12 (1984).

D. K. Christen, H. R. Kerchner, A. DasGupta, and S. T. Sekula, "The Flux-Line Lattice in a Niobium Bicrystal," abstract, *J. Met.* 5(12), 52 (December 1983).

H. C. Claiborne, A. G. Croff, J. C. Griess, and F. J. Smith, *Repository Environmental Parameters Relevant to Assessing the Performance of High-Level Waste Packages*, NUREG/CR-4134, ORNL/TM-9522, February 1985.

R. E. Clausing and L. Heatherly, "Control of Surface Composition and Hydrogen Recycling by Plasma Conditioning," *J. Nucl. Mater.* 128&129, 855-60 (1984).

R. E. Clausing, F. Waelbroeck, J. Winter, P. Wienhold, and L. Könen, "Effects of Wall Conditioning on Plasma Parameters, Impurities and Hydrogen Recycling in TEXTOR," *J. Nucl. Mater.* 121, 249-53 (1984).

R. W. Conn, E. E. Bloom, J. W. Davis, R. E. Gold, R. Little, K. R. Schultz, D. L. Smith, and F. W. Wiffen, *Report of the DOE Panel on Low Activation Materials for Fusion Applications*, PPG-728, Center for Plasma Physics and Fusion Engineering, University of California, Los Angeles, June 1983.

R. H. Cooper, Jr., "Potential Refractory Alloy Requirements for Space Nuclear Power Applications," pp. 14-17 in *Refractory Alloy Technology for Space Nuclear Power Applications*, proceedings of symposium held in Oak Ridge, Tenn., on Aug. 10-11, 1983, CONF-8308130 (DE84001745), ed. R. H. Cooper, Jr., and E. E. Hoffman, Technical Information Center, U.S. Department of Energy, Oak Ridge, Tenn., 1984.

R. H. Cooper, Jr., "Refractory Alloy Characterization," pp. 1-8 in *SP-100 Program, Proceedings of the First Program Integration Meeting, June 13-15, 1984, Danvers, Mass.*, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, July 1984.

W. R. Corwin, *Assessment of Radiation Effects Relating to Reactor Pressure Vessel Cladding*, NUREG/CR-3671, ORNL-6047, July 1984.

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 Overlay*, NUREG/CR-3927, ORNL/TM-9309, September 1984.

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 MoV Ferritic Steel," *J. Nucl. Mater.* 122&123, 343-48 (1984).

B. Craseman, M. H. Chen, G. B. Armen, J. Levin, G. E. Ice, and G. S. Brown, "Atomic Inner-Shell Threshold Excitation Phenomena Investigated by Electron Spectroscopy," pp. VII-44-45 in *SSRL 83/01 Activity Report, April 1, 1982-March 31, 1983*, ed. K. Cantwell, Stanford Synchrotron Radiation Laboratory, Stanford, Calif., 1983.

J. E. Cunningham, "Development of Ductile Polycrystalline Ni₃Al," pp. 11-18 in *Minutes of ATAC's 30 March 1982 Meeting*, Advisory Technical Awareness Council, American Society for Metals, Metals Park, Ohio, Apr. 16, 1982.

J. E. Cunningham, "Fusion Reactor Materials," pp. 79-88 in *Minutes of ATAC's 3 October 1983 Meeting*, Advisory Technical Awareness Council, American Society for Metals, Metals Park, Ohio, Nov. 11, 1983.

J. E. Cunningham, "Recent Developments in Graphite," pp. 1-4 in *Minutes of ATAC's 16 March 1983 Meeting*, Advisory Technical Awareness Council, American Society for Metals, Metals Park, Ohio, Apr. 8, 1983.

J. E. Cunningham, "Synchrotron Radiation Research," pp. 48-50 in *Minutes of ATAC/MPEC 25 October 1982 Meeting*, Advisory Technical Awareness Council, American Society for Metals, Metals Park, Ohio, Dec. 2, 1982.

A. DasGupta, J. A. Horton, and C. T. Liu, "Phase Formation and Stability in the Pseudobinary Ni₃Al-Ni₃V Alloy System," pp. 115-23 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

S. A. David, W. A. Jemian, C. T. Liu, and J. H. Horton, "Welding and Weldability of Nickel-Iron Aluminides," *Weld. J.* 64(10), 22-28-s (January 1985).

R. F. Davis, C. H. Carter, Jr., S. Chevacharoenkul, and J. Bentley, "The Occurrence and Behavior of Dislocations During Plastic Deformation of Selected Transition Metal and Silicon Carbides," pp. 97-124 in *Deformation of Ceramics II*, proceedings of Second International Conference on Plastic Deformation in Ceramics held at Pennsylvania State University, University Park, Pa., July 1983, ed. R. E. Tressler and R. C. Bradt, Plenum Publishing Corporation, New York, 1984.

J. H. DeVan, J. R. DiStefano, and E. E. Hoffman, "Compatibility of Refractory Alloys with Space Reactor Coolants and Working Fluids," pp. 34-85 in *Refractory Alloy Technology for Space Nuclear Power Applications*, proceedings of symposium held in Oak Ridge, Tenn., on Aug. 10-11, 1983, CONF-8308130 (DE84001745), ed. R. H. Cooper, Jr., and E. E. Hoffman, Technical Information Center, U.S. Department of Energy, Oak Ridge, Tenn., January 1984.

C. V. Dodd, C. D. Cox, and W. E. Deeds, "Experimental Verification of Eddy-Current Flaw Theory," pp. 359-64 in *Review of Progress in Quantitative Nondestructive Evaluation, Vol. 4A*, first half of proceedings of Eleventh Annual Review of Progress in Quantitative Nondestructive Evaluation held at University of California, San Diego, July 8-13, 1984, ed. D. O. Thompson and D. E. Chimenti, Plenum Publishing Corporation, New York, 1984.

C. V. Dodd, W. E. Deeds, J. H. Smith, and R. W. McClung, *Eddy-Current Inspection for Steam Generator Tubing Program Quarterly Progress Report for Period Ending June 30, 1983*, NUREG/CR-3200, Vol. 2, ORNL/TM-8796/V2, September 1983.

C. V. Dodd, W. E. Deeds, J. H. Smith, and R. W. McClung, *Eddy-Current Inspection for Steam Generator Tubing Program Quarterly Progress Report for Period Ending September 30, 1983*, NUREG/CR-3200, Vol. 3, ORNL/TM-8796/V3, March 1984.

C. V. Dodd, W. E. Deeds, J. H. Smith, and R. W. McClung, *Eddy-Current Inspection for Steam Generator Tubing Program Annual Progress Report for Period Ending December 31, 1983*, NUREG/CR-3200, Vol. 4, ORNL/TM-8796/V4, May 1984.

C. V. Dodd, W. E. Deeds, J. H. Smith, and R. W. McClung, *Eddy-Current Inspection for Steam Generator Tubing Program Semiannual Progress Report for Period Ending June 30, 1984*, NUREG/CR-3949, Vol. 1, ORNL/TM-9339/V1, December 1984.

W. P. Eatherly and G. B. Engle, "Recent Developments in Graphite for HTGR Applications," pp. 216-17 in *Transactions of the American Nuclear Society*, proceedings of 1983 American Nuclear Society meeting held in Detroit on June 12-16, 1983, vol. 44, ed. L. Palagi, American Nuclear Society, La Grange Park, Ill., 1983.

W. P. Eatherly and D. A. Lee, "Corrosion-Induced Microstructural Changes in a U.S. Core Graphite," pp. 37-40 in *Transport of Fission Products in Matrix and Graphite*, proceedings of a colloquium held at the Hahn-Meitner-Institut für Kernforschung, Berlin, on Nov. 9-11, 1981, HMI-B 372, ed. E. Hoinkis, Nuclear Chemistry and Reactor Division, Berlin, June 1983.

D. P. Edmonds, T. B. Cox, J. F. King, R. K. Nanstad, R. A. Swift, and R. W. Swindeman, *Evaluation of 3 Cr-1.5 Mo-0.1 V Steel as a Gasifier Pressure Vessel Alloy*, ORNL-6106, January 1985.

L. C. Emerson, P. K. Mioduszewski, and J. E. Simpkins, "Performance of Zr-Al Getter Pumps Under Transient Load Conditions," *J. Vac. Sci. Technol.* A2(4), 1583-88 (October-December 1984).

G. C. Farlow, C. W. White, C. J. McHargue, and B. R. Appleton, "Behavior of Implanted α -Al₂O₃ in an Oxidizing Annealing Environment," pp. 395-400 in *Ion Implantation and Ion Beam Processing of Materials*, proceedings of symposium held in Boston in November 1983, ed. G. K. Hubler, O. W. Holland, C. R. Clayton, and C. W. White, Materials Research Symposia Proceedings, vol. 27, North-Holland, New York, 1984.

K. Farrell, "Response of Aluminum and Its Alloys to Exposure in the High Flux Isotope Reactor," paper P11 in *Dimensional Stability and Mechanical Behavior of Irradiated Metals and Alloys*, proceedings of Nuclear Energy Society Meeting, Brighton, England, Apr. 11-13, 1983, British Nuclear Energy Society, London, 1983.

M. K. Ferber, "A Mathematical Description of Transient Crack Growth Behavior in Glass," *J. Mater. Sci.* 19, 2570-4 (1984).

M. K. Ferber, H. D. Kimrey, and P. F. Becher, "Mechanical Reliability of Ceramic Windows in High Frequency Microwave Heating Devices: Part 1 An Analysis of Temperature and Stress Distributions," *J. Mater. Sci.* 19, 3767-77 (1984).

M. K. Ferber and V. J. Tennery, "Behavior of Tubular Ceramic Heat Exchanger Materials in Basic Coal Ash from Coal-Oil-Mixture Combustion," *Am. Ceram. Soc. Bull.* 63(7), 898-904 (July 1984).

M. K. Ferber, V. J. Tennery, and J. F. Willmering, *Exposure of Tubular Ceramic Heat Exchanger Materials to Refractory Coal Ash from Coal-Oil-Mixture Combustion*, ORNL/TM-9052, September 1984.

C. B. Finch, O. B. Cavin, and P. F. Becher, "Crystal Growth and Properties of Trinickel Boride, Ni₃B," *J. Cryst. Growth* 67, 556-58 (1984).

C. B. Finch, M. K. Ferber, W. A. Simpson, Jr., and R. K. Williams, "Anisotropy of Thermal Expansion, Elasticity, and Electrical Resistivity in Single-Crystal Trinickel Boride, Ni₃B," *J. Mater. Sci. Lett.* 3, 1074-76 (1984).

J. R. Gibson and D. N. Braski, *Scanning Electron Microscope Facility for Examination of Radioactive Materials*, ORNL/TM-9451, February 1985.

G. M. Goodwin, *Fracture Toughness of Austenitic Stainless Steel Weld Metal at 4 K*, ORNL/TM-9172, August 1984.

G. M. Goodwin and R. K. Nanstad, *Effect of Temperature on the Stress-Relaxation Response of a Pressure Vessel Steel*, NUREG/Cr-3728, ORNL/TM-9149, October 1984.

J. C. Griess, "Considerations in Estimating Corrosion of Metallic Containers in Nuclear Waste Repositories," pp. 599-601 in *Waste Management '84: Waste Isolation in the U.S., Technical Programs and Public Education. Waste Policies and Programs, High-Level Waste*, proceedings of symposium held in Tucson, Ariz., on Mar. 11-15, 1984, vol. 1, ed. R. G. Post, sponsored by American Nuclear Society, Radwaste Systems Committee of the American Society of Mechanical Engineers, Electric Power Research Institute, University of Arizona College of Engineering, and U.S. Department of Energy, American Nuclear Society, La Grange Park, Ill., 1984.

J. C. Griess, "Problems in Estimating Corrosion in Nuclear Waste Repositories," p. 403 in *Extended Abstracts*, vol. 84-2, fall meeting held in New Orleans on Oct. 7-12, 1984, The Electrochemical Society, Princeton, N.J., 1984.

J. C. Griess, S. A. David, and R. J. Gray, "Electrochemical Etching of Titanium Alloy Castings," *J. Appl. Electrochem.* 14, 573-85 (1984).

D. J. Griffiths, D. S. Easton, and D. M. Kroeger, "Critical Exponents of Amorphous $Gd_{0.70}Pd_{0.30}$," *Phys. Rev. B* 31(1), 287-92 (January 1985).

M. L. Grossbeck and K. C. Liu, "Fatigue Performance of HFIR-Irradiated Nimonic PE-16 at 430°C," *J. Nucl. Mater.* 122&123, 682-86 (1984).

B. L. Gyorffy, J. Kollar, A. J. Pindor, G. M. Stocks, J. Staunton, and H. Winter, "On the Theory of Ferro-Magnetism of Transition Metals at Finite Temperatures," pp. 593-656 in *The Electronic Structure of Complex Systems*, proceedings of a NATO Advanced Study Institute held at State University of Ghent, Belgium, on July 12-23, 1982, vol. 113, ed. P. Phariseau and W. M. Temmerman, Plenum Publishing Corporation, New York, 1984.

B. L. Gyorffy, J. B. Staunton, and G. M. Stocks, "Ferromagnetism in Metals at Finite Temperatures," pp. 231-47 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

L. A. Harris, C. R. Kennedy, G. C. Wei, and F. P. Jeffers, "Microscopy of SiC Powders Synthesized by Reacting Colloidal Silica and Pitch," *J. Am. Ceram. Soc.* 67(6), C-121-24 (June 1984).

B. Heshmatpour and R. L. Heestand, "Recovery of Iridium from Scrap and Residues," *J. Less-Common Met.* 105, 119-28 (1985).

A. Hishinuma, N. H. Packan, E. H. Lee, and L. K. Mansur, "Effects of Pulsed and/or Dual Ion Irradiation on Microstructural Evolution in a Ti and Si Modified Austenitic Alloy," *J. Nucl. Mater.* 122&123, 260-65 (1984).

A. Hishinuma, J. M. Vitek, J. A. Horak, and E. E. Bloom, "Effect of Preinjected Helium on Swelling and Microstructure of Neutron Irradiated Pressurized Tubes of Type 316 Stainless Steel," pp. 92-107 in *Effects of Radiation on Materials*, proceedings of the 11th International Symposium held in Scottsdale, Ariz., on June 28-30, 1982, ASTM STP 782, ed. H. R. Brager and J. S. Perrin, American Society for Testing and Materials, Philadelphia, 1982.

L. L. Horton, "Experimental Determination of the Critical Cavity Radius in Fe-10% Cr for Ion Irradiation," *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

L. L. Horton and J. Bentley, "Swelling Behavior of a Simple Ferritic Alloy," pp. 569-78 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies, Snowbird, Utah, June 19-23, 1983*, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

L. L. Horton and K. Farrell, "The Temperature Dependence of the Damage Microstructures in Neutron-Irradiated Vanadium," *J. Nucl. Mater.* 122&123, 687-92 (1984).

J. A. Horton, A. DasGupta, and C. T. Liu, "The Disordering Process in an L1₂ Ordered Alloy," *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

J. A. Horton, C. T. Liu, and C. C. Koch, "Alloying Effects and Microstructure of Iron Aluminides," pp. 309-21 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of The Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

G. E. Ice and C. J. Sparks, Jr., "Focusing Optics for a Synchrotron X-Radiation Microprobe," *Nucl. Instrum. Methods* 222, 21-27 (1984).

H. Inouye, "Niobium in High Temperature Applications," p. 615 in *Proceedings of the International Symposium Niobium '81*, held in San Francisco on Nov. 8-11, 1981, ed. H. Stuart, Metallurgical Society of AIME, Warrendale, Pa., 1981.

H. Inouye, "Relationship of H_2O and CH_4 Supply Rates in HTGR Helium to the Carburization of Hastelloy-X and Alloy 800H," *Nucl. Technol.* **66**, 392-403 (August 1984).

H. Inouye and S. A. David, "Segregation and Influence of Boron on the Impact Toughness of Ti-6 Pct Al-2 Pct Nb-1 Pct Ta-0.8 Pct Mo Welds and Castings," *Metall. Trans. A* **15A**, 1505-08 (July 1984).

D. D. Johnson, F. J. Pinski, and G. M. Stocks, "Fast Method for Calculating the Self-Consistent Electronic Structure of Random Alloys," *Phys. Rev. B* **30**(10), 5508-15 (November 1984).

D. D. Johnson, F. J. Pinski, and G. M. Stocks, "Self-Consistent Electronic Structure of Disordered $Fe_{0.65}Ni_{0.35}$," *J. Appl. Phys.* **57**(1), 3018-20 (1985).

D. R. Johnson, comp., *Ceramic Technology for Advanced Heat Engines Project Semiannual Progress Report for Period March 1983-September 1983*, ORNL/TM-9325, October 1984.

D. R. Johnson, comp., *Ceramic Technology for Advanced Heat Engines Project Semiannual Progress Report for Period October 1983-March 1984*, ORNL/TM-9466, December 1984.

D. R. Johnson, A. C. Schaffhauser, V. J. Tennery, E. L. Long, Jr., and R. B. Schulz, "Ceramic Technology for Advanced Heat Engines Project," *Am. Ceram. Soc. Bull.* **64**(2), 276-81 (1985).

R. R. Judkins, W. L. Greenstreet, J. P. Hammond, J. R. Horton, and A. C. Raptis, *Assessment of the Performance of Instrumentation, Materials, and Components in the Bi-Gas Coal Gasification Pilot Plant*, ORNL/TM-9134, October 1984.

J. R. Keiser, A. R. Olsen, R. R. Judkins, J. W. Nave, and J. W. Jones, *Inspection of Selected Vessels of the H-Coal Pilot Plant at Catlettsburg, Kentucky*, ORNL-6036, July 1984.

J. R. Keiser, A. R. Olsen, J. F. Newsome, and M. Howell, *Corrosion Studies at the Wilsonville, Alabama, Coal Liquefaction Facility During 1983*, ORNL/TM-9194, October 1984.

E. A. Kenik, "Shared Research Equipment (SHaRE) Program," *Electron Microsc. Soc. Bull.* **14**(1), 33-4 (1984).

E. A. Kenik and P. J. Maziasz, "Application of Extraction Replicas and Analytical Electron Microscopy to Precipitate Phase Studies," pp. 231-34 in *Analytical Electron Microscopy 1984*, proceedings of workshop held at Bethlehem, Pa., July 16-20, 1984, sponsored by Microbeam Analysis Society, ed. D. B. Williams and D. C. Joy, San Francisco Press, San Francisco, 1984.

H. R. Kerchner, D. K. Christen, A. DasGupta, and S. T. Sekula, "Flux-Line Pinning by the Grain Boundary in Niobium Bicrystals," pp. 463-64 in *Proceedings of the 17th International Conference on Low Temperature Physics, LT-17, Part II - Contributed Papers, Universität Karlsruhe and Kernforschungszentrum Karlsruhe, Federal Republic of Germany, August 15-22, 1984*, Elsevier Science Publishers, The Netherlands, 1984.

S. Kim, J. P. Weertman, S. Spooner, C. J. Glinka, V. Sikka, and W. B. Jones, "Microstructural Evaluation of a Ferritic Stainless Steel by Small Angle Neutron Scattering," pp. 169-76 in *Nondestructive Evaluation: Application to Materials Processing*, proceedings of symposium sponsored by the Energy and Resources Activity of the American Society for Metals at the TMS Fall Meeting, Philadelphia, Oct. 3-4 1983, ed. C. Buck and S. M. Wolf, American Society for Metals, Metals Park, Ohio, 1983.

J. F. King and H. E. McCoy, *Weldability and Mechanical Property Characterization of Weld Clad Alloy 800H Tubesheet Forging*, ORNL/TM-9108, September 1984.

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," *J. Nucl. Mater.* 122&123, 294-98 (1984).

R. L. Klueh and R. W. Swindeman, "Creep Behavior of a Modified 2 1/4 Cr-1 Mo Steel for Pressure Vessel Applications," abstract, p. 63 in *The Metallurgical Society Fall Meeting*, program of meeting held in Philadelphia, Oct. 2-6, 1983, The Metallurgical Society of AIME, New York, 1983.

R. L. Klueh and J. M. Vitek, "Elevated-Temperature Tensile Properties of Irradiated 2 1/4 Cr-1 Mo Steel," *J. Nucl. Mater.* 126, 9-17 (1984).

R. L. Klueh and J. M. Vitek, "Tensile Behavior of Three Commercial Ferritic Steels After Low-Temperature Irradiation," pp. 615-22 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies* held in Snowbird, Utah, on June 19-23, 1983, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

C. C. Koch, D. M. Kroeger, C. G. McKamey, and J. O. Scarbrough, "The Thermal and Mechanical Stability of $\text{Fe}_{90-x}\text{Al}_x\text{Zr}_{10}$ Metallic Glasses," *Acta Metall.* 32(11), 2053-61 (1984).

O. C. Kopp and O. B. Cavin, "Hydrothermal Growth of Single Crystal Cu_2Se (Berzelianite)," *J. Cryst. Growth* **67**, 391-92 (1984).

P. Krautwasser and W. P. Eatherly, "Corrosion-Induced Changes in Pore Size Distributions of Fuel Matrix Material," pp. 33-36 in *Transport of Fission Products in Matrix and Graphite*, proceedings of a colloquium held at the Hahn-Meitner-Institut für Kernforschung, Berlin, on Nov. 9-11, 1981, HMI-B 372, ed. E. Hoinkis, Nuclear Chemistry and Reactor Division, Berlin, June 1983.

W. J. Lackey, P. Angelini, A. J. Caputo, C. E. DeVore, J. C. McLaughlin, D. P. Stinton, and R. E. Hutchens, "Rate-Controlled Technique for Calcining and Drying," *J. Am. Ceram. Soc.* **67**(6), C-102-4 (June 1984).

W. J. Lackey, D. P. Stinton, G. A. Cerny, L. L. Fehrenbacher, and A. C. Schaffhauser, *Ceramic Coatings for Heat Engine Materials - Status and Future Needs*, ORNL/TM-8959, December 1984.

W. J. Lackey, D. P. Stinton, G. A. Cerny, L. L. Fehrenbacher, and A. C. Schaffhauser, "Ceramic Coatings for Heat Engine Materials - Status and Future Needs," pp. 770-82 in *Proceedings of the First International Symposium on Ceramic Components for Engines* held in Hakone, Japan, on Oct. 17-19, 1983, ed. S. Soniya, E. Kanai, and K. Ando, KTK Scientific Publishers, Tokyo, D. Reidel Publishing Co., Dordrecht, Boston, Lancaster, 1983.

R. J. Lauf, "Irradiation Performance of Pyrolytic Silicon Carbide Coatings on Fissile Fuel Particles," *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

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," *J. Nucl. Mater.* **122&123**, 299-304 (1984).

E. H. Lee, A. F. Rowcliffe, and L. K. Mansur, "Precipitation and Cavity Formation in Austenitic Stainless Steels During Irradiation," *J. Nucl. Mater.* **103&104**, 1475-80 (1981).

M. B. Lewis, "Deuterium-Defect Trapping in Ion-Irradiated Zirconium," *J. Nucl. Mater.* **125**, 152-59 (1984).

M. B. Lewis, "Improved Extraction of Zirconium and Molybdenum Beams from a Penning Discharge Ion Source," *Nucl. Instrum. Methods Phys. Res.* **219**, 247-49 (1984).

M. B. Lewis, "Long-Range Recoil Extension of High Energy Heavy Ion Damage in Ceramics," *Nucl. Instrum. Methods. Phys. Res. B* **7**(8), 530-34 (1985).

M. B. Lewis and C. J. McHargue, "High Energy Ion Beam Mixing in Al_2O_3 ," pp. 771-76 in *Ion Implantation and Ion Beam Processing*, proceedings of symposium held in Boston in November 1983, ed. G. K. Hubler, O. W. Holland, C. R. Clayton, and C. W. White, Materials Research Society Symposia Proceedings, vol. 27, North-Holland, New York, 1984.

M. B. Lewis and C. J. McHargue, "High Energy Ion Beam Mixing in Al_2O_3 ," pp. 771-76 in *Defect Properties and Processing of High-Technology Nonmetallic Materials*, proceedings of symposium held in Boston on Nov. 14-18, 1983, ed. J. H. Crawford, Jr., Y. Chen, and W. A. Sibley, Materials Research Society Symposia Proceedings, vol. 24, Elsevier, New York, 1984.

M. B. Lewis and G. K. Schulze, "Chopped Ion Beams for Radiation Effects Simulation," *Nucl. Instrum. Methods B9*, 100-102 (1985).

C. T. Liu, "Design of Ordered Intermetallic Alloys for High-Temperature Structural Use," pp. 289-308 in *High Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

C. T. Liu, "Physical Metallurgy and Mechanical Properties of Ductile Ordered Alloys $(\text{Fe,Co,Ni})_3\text{V}$," *Int. Met. Rev.* 29(3), 168-94 (1984).

C. T. Liu, W. Jemian, H. Inouye, J. V. Cathcart, S. A. David, J. A. Horton, and M. L. Santella, *Initial Development of Nickel and Nickel Iron Aluminides for Structural Uses*, ORNL-6067, August 1984.

C. T. Liu and J. O. Stiegler, "Ductile Ordered Intermetallic Alloys," *Sci.* 226, 636-42 (1984).

C. T. Liu and J. O. Stiegler, "Ordered Intermetallic Alloys; High Temperature Structural Materials of the Future?," *Mater. Eng.* 100(5), 29-33 (1984).

C. T. Liu and N. S. Stoloff, *Development and Characterization of Ductile Long-Range-Ordered (LRO) Alloys $(\text{Fe,Co,Ni})_3\text{V}$ for High-Temperature Structural Use*, ORNL-6032, August 1984.

C. T. Liu, C. L. White, and J. A. Horton, "Effect of Boron on Grain-Boundaries in Ni_3Al ," *Acta Metall.* 33(2), 213-29 (1985).

K. C. Liu and C. M. Loring, Jr., "Low-Cycle Fatigue Behavior of Oxygen-Free High-Conductivity Copper at 300°C in High Vacuum," *J. Nucl. Mater.* 122&123, 783-88 (1984).

T. S. Lundy, "Insulation Needs Further Study," pp. 41-43 in *BPA's Sixth Annual Energy Conservation Management Conference*, proceedings of meeting held in Seattle on Mar. 26-28, 1979, Bonneville Power Administration, Portland, Oreg., 1979.

T. S. Lundy, "National Program Planning: Philosophy and Example," pp. K-168-74 in *Doing Better: Setting an Agenda for the Second Decade*, proceedings from Panels on Improving Methods of Program Evaluation, vol. K, ACEEE 1984 Summer Study on Energy Efficiency in Buildings held in Santa Cruz, Calif., on Aug. 14-22, 1984, American Council for an Energy Efficient Economy, Washington, D.C., August 1984.

T. S. Lundy, "Report from Oak Ridge National Laboratory," *J. Thermal Insul.* 7, 260-63 (April 1984).

T. S. Lundy, "Report from Oak Ridge National Laboratory," *J. Thermal Insul.* 8, 165-66 (January 1985).

J. E. Mack and L. C. Williams, "Processing Capabilities for the Elimination of Contaminated Metal Scrapyards at DOE/ORO-Managed Sites," pp. 431-38 in *Waste Management '82; Waste Isolation in the U.S. and Elsewhere, Technical Programs and Public Communications*, proceedings of the Symposium on Waste Management held in Tucson, Ariz., on Mar. 8-11, 1982, vol. 1, ed. R. G. Post, sponsored by American Nuclear Society, Radwaste Systems Committee of the American Society of Mechanical Engineers, The University of Arizona College of Engineering, and U.S. Department of Energy, The University of Arizona, Tucson, Ariz., 1982.

A. P. Maclin and G. M. Stocks, "Band-Structure Calculations of Aluminides," pp. 249-55 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

L. K. Mansur, A. D. Brailsford, and W. A. Coghlan, *A Cascade Diffusion Theory of Sink Capture Fluctuations During Irradiation of a Solid*, ORNL-6123, January 1985.

P. J. Maziasz, "Comparison of Swelling and Cavity Microstructural Development for Type 316 Stainless Steel Irradiated in EBR-II and HFIR," *J. Nucl. Mater.* 122&123, 236-41 (1984).

P. J. Maziasz, "Molybdenum Solubility Differences in MC Phases Formed in Titanium and Niobium Modified Austenitic Stainless Steels Determined Using AEM," pp. 496-97 in *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

P. J. Maziasz, "Swelling and Swelling Resistance Possibilities of Austenitic Stainless Steels in Fusion Reactors," *J. Nucl. Mater.* 122&123, 472-86 (1984).

P. J. Maziasz and D. N. Braski, "Improved Swelling Resistance for PCA Austenitic Stainless Steel Under HFIR Irradiation Through Microstructural Control," *J. Nucl. Mater.* 122&123, 311-16 (1984).

P. J. Maziasz and D. N. Braski, "Microstructural Design of PCA Austenitic Stainless Steel for Improved Resistance to Helium Embrittlement Under HFIR Irradiation," *J. Nucl. Mater.* 122&123, 305-10 (1984).

H. E. McCoy, J. P. Strizak, and J. F. King, "Hastelloy-X for High-Temperature Gas-Cooled Reactor Applications," *Nucl. Technol.* 66, 161-74 (July 1984).

D. L. McElroy, G. J. Hyland, and J. Ralph, "High-Temperature Thermophysical Properties of Nuclear Oxide Fuels," pp. 103-7 in *Eighth European Conference on Thermophysical Properties*, proceedings of meeting held in Baden-Baden, Federal Republic of Germany, Sept. 27-Oct. 1, 1982, under the auspices of the Deutsche Keramische Gesellschaft and Its Thermo-Physical Working Group, Pion Limited, London, 1984.

D. L. McElroy, G. Neuner, and R. P. Tye, "Thermophysical Properties of Industrial Insulators," *High Temp. High Pressures* 16, 109-14 (1984).

D. L. McElroy, D. W. Yarbrough, G. L. Copeland, F. J. Weaver, R. S. Graves, T. W. Tong, and H. A. Fine, *Development of Advanced Thermal Insulation for Appliances*, ORNL/CON-159, July 1984.

J. J. McGowan, *Recommended Research to Protect Coal Liquefaction Vessels Against Non-Ductile Failure*, ORNL/TM-9-73, January 1985.

J. J. McGowan, *Tensile Properties of Irradiated Nuclear Grade Pressure Vessel Plate and Welds for the Fourth HSST Irradiation Series*, NUREG/CR-3978, ORNL/TM-9516, January 1985.

J. J. McGowan, *Tensile Properties of Irradiated Nuclear Grade Pressure Vessel Welds for the Third HSST Irradiation Series*, NUREG/CR-4086, ORNL/TM-9477, March 1985.

J. J. McGowan and R. K. Nanstad, "A Direct Comparison of Unloading Compliance and Potential Drop Techniques in J-Integral Testing," pp. 136-40 in *Proceedings of the 1984 SEM Fall Conference 'Computer-Aided Testing and Modal Analysis'* held in Milwaukee on Nov. 4-7, 1984, Society for Experimental Mechanics, Brookfield Center, Conn., 1984.

C. J. McHargue, B. R. Appleton, and C. W. White, "Structure Property Relationships in Ion Implanted Ceramics," pp. 228-42 in *Surface Engineering, Surface Modification of Materials*, proceedings of NATO Advanced Study Institute on Surface Engineering meeting held in Les Arcs, France, on July 13-15, 1983, Series E, Applied Sciences, No. 85, ed. R. Kossowsky and S. C. Singhal, Advanced Study Institute on Surface Engineering, Martinus Nijhoff Publishers, Dordrecht, The Netherlands, 1984.

C. J. McHargue, G. C. Farlow, C. W. White, J. M. Williams, B. R. Appleton, and H. Naramoto, "The Amorphization of Ceramics by Ion Beams," *Mater. Sci. Eng.* 69, 123-27 (1985).

C. J. McHargue, M. B. Lewis, J. M. Williams, and B. R. Appleton, "The Reactivity of Ion-Implanted SiC," *Mater. Sci. Eng.* 69, 391-95 (1985).

C. J. McHargue, H. Naramoto, C. W. White, J. M. Williams, B. R. Appleton, P. S. Sklad, and P. Angelini, "Structure of Ceramic Surfaces Modified by Ion Beam Techniques," pp. 519-31 in *Emergent Process Methods for High-Technology Ceramics*, proceedings of 19th University Conference on Ceramic Science held in Raleigh, N.C., on Nov. 8-10, 1982, ed. R. F. Davis, H. Palmour III, and R. L. Porter, Materials Science Research, vol. 17, Plenum Press, New York, 1984.

C. J. McHargue and Sigfred Peterson, *Metals and Ceramics Division Materials Science Program Annual Progress Report for Period Ending June 30, 1984*, CRNL/TM-9357, November 1984.

C. J. McHargue, C. W. White, B. R. Appleton, G. C. Farlow, and J. M. Williams, "Ion Beam Modification of Ceramics," pp. 385-93 in *Defect Properties and Processing of High-Technology Nonmetallic Materials*, proceedings of symposium held in Boston on Nov. 14-18, 1983, ed. J. H. Crawford, Jr., Y. Chen, and W. A. Sibley, Materials Research Society Symposia Proceedings, vol. 24, Elsevier, New York, 1984.

J. J. Mecholsky, P. F. Becher, and S. W. Freiman, "Relationship Between Surface Structure, Ceramic Processing and Mechanical Properties," pp. 189-215 in *Surface Treatments for Improved Performance and Properties*, proceedings of 26th Sagamore Army Materials Research Conference held in Lake George, N.Y., on July 16-20, 1979, ed. J. J. Burke and V. Weiss, Plenum Press, New York, 1982.

M. K. Miller, "Imaging Atom Probe Computer Experiments," pp. C9-337-42 in *31st International Field Emission Symposium, Paris, France, July 16-20, 1984*, ed. P. Sudraud and P. Ballongue, Tome 45, Colloque C9, supplement au n° 12, Journal de Physique, Les Ulis Cedex, France, Décembre 1984.

M. K. Miller, J. Bentley, S. S. Brenner, and J. A. Spitznagel, "Long Term Thermal Aging of Type CF 8 Stainless Steel," pp. C9-385-90 in *31st International Field Emission Symposium, Paris, France, July 16-20, 1984*, ed. P. Sudraud and P. Ballongue, Tome 45, Colloque C9, supplement au n° 12, Journal de Physique, Les Ulis Cedex, France, Décembre 1984.

M. K. Miller, S. S. Brenner, M. G. Burke, and W. A. Soffa, "Atom Probe Field-Ion Microscopy Studies of Triaxially Modulated Microstructures in Fe-Be Alloys," *Scr. Metall.* 18, 111-16 (1984).

M. K. Miller, S. S. Brenner, P. P. Camus, and W. A. Soffa, "The Atom Probe - A Direct Technique for Kinetic Measurements," pp. 63-66 in *Proceedings of International Topical Conference on Kinetics of Aggregation and Gelation, Athens, Georgia, Apr. 2-4, 1984*, ed. F. Family and D. P. Landau, North-Holland Publishers, New York, 1984.

M. K. Miller, M. G. Burke, and S. S. Brenner, "Morphological Interpretation of Modulated Microstructures," pp. C9-239-44 in *31st International Field Emission Symposium, Paris, France, July 16-20, 1984*, ed. P. Sudraud and P. Ballongue, Tome 45, Colloque C9, supplement au n° 12, Journal de Physique, Les Ulis Cedex, France, Décembre 1984.

M. K. Miller, M. G. Burke, S. S. Brenner, W. A. Soffa, K. E. Alexander, and D. E. Laughlin, "Identification of B32 Metastable Precipitate in the Fe-Be System," *Scr. Metall.* 18, 285-90 (1984).

K. Miyahara, N. H. Packan, and N. Igata, "The Effect of Pulsed Irradiation on Void Swelling of a Pure Austenitic Alloy," *J. Nucl. Mater.* 122&123, 624-28 (1984).

J. P. Moore, "Analysis of Apparatus with Radial Symmetry for Steady-State Measurements of Thermal Conductivity," pp. 61-123 in *Compendium of Thermophysical Property Measurement Methods*, vol. 1, ed. K. D. Maglic, Plenum Press, New York, 1984.

L. E. Morris and J. A. Carpenter, Jr., *Materials Project of the Energy Conversion and Utilization Technologies (ECUT) Program Progress Report for Year Ending September 30, 1982*, ORNL/TM-8940, August 1984.

J. Narayan, D. Fathy, O. W. Holland, B. R. Appleton, R. F. Davis, and P. F. Becher, "Ion-Beam and Laser Mixing of Nickel Overlayers on Silicon Carbide," *J. Appl. Phys.* 56(6), 1577-82 (September 1984).

D. Nicholson and A. Chowdhary, "Electronic Structure of Liquid Metal Alloys," pp. 257-64 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by the Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

W. C. Oliver, R. Hutchings, and J. B. Pethica, "The Wear Behavior of Nitrogen-Implanted Metals," *Metall. Trans. A* 15A, 2221-29 (December 1984).

A. R. Olsen and J. R. Keiser, *SRC-1 Demonstration Plant - Summary of the Materials Design Selection Review*, ORNL-6116, April 1985.

N. H. Packan, "Temperature Aspects of Pulsed Ion Bombardment in an Austenitic Alloy," *J. Nucl. Mater.* 122&123, 644-49 (1984).

P. Patriarca, "Use of Ferritic Steels in Breeder Reactors Worldwide," pp. 107-12 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies, Snowbird, Utah, June 19-23, 1983*, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

E. Pérez, C. Kohut, D. Giorsetti, G. Copeland, and J. Snelgrove, "Irradiation Performance on CNEA UAl_x and U₃O₈ Miniplates," pp. 67-75 in *Proceedings of the International Meeting on Development, Fabrication and Application of Reduced Enrichment Fuels for Research and Test Reactors, Argonne, Illinois, November 12-14, 1980*, ANL/RERTR/TH-3, CONF-801144, Reduced Enrichment Research and Test Reactor Program, Argonne National Laboratory, Argonne, Ill., August 1983.

J. Petermann, R. M. Gohil, J. M. Schultz, R. W. Hendricks, and J. S. Lin, "The Kinetics of Defect Clustering in Fibrillar Polypropylene Crystals," *J. Polym. Sci.* 20, 523-34 (1982).

J. M. Robbins, M. J. Kania, and E. L. Long, Jr., "Gas Content Measurements of Irradiated Coated Particles Using the PGA System," paper P29 in *Post-Irradiation Examination*, proceedings of International Conference held in Grange-Over-Sands, England, on May 13-15, 1980, British Nuclear Energy Society, London, 1980.

A. F. Rowcliffe and M. L. Grossbeck, "The Response of Austenitic Steels to Radiation Damage," *J. Nucl. Mater.* 122&123, 181-90 (1984).

A. F. Rowcliffe and E. H. Lee, "The Stability of the MC Phase in a Stainless Steel Irradiated in Various Environments," pp. 5-9 in *Dimensional Stability and Mechanical Behavior of Irradiated Metals and Alloys*, vol. 2, proceedings of conference held in Brighton, England, on Apr. 11-13, 1983, British Nuclear Energy Society, London, 1984.

J. H. Schneibel and G. F. Petersen, "Grain Boundary Sliding in Nickel Wires Having a Bamboo Structure," *Acta Metall.* 33(3), 437-42 (1985).

J. H. Schneibel, G. F. Petersen, and M. H. Yoo, "Grain Boundary Sliding and Segregation," *J. Met.* 35(8), 60 (August 1983).

J. H. Schneibel and H. Trinkaus, "Cavitation in the Diffusional Creep Regime," *J. Met.* 35(8), 17 (August 1983).

J. H. Schneibel and C. L. White, "The Effect of Small Alloying Additions on the Creep Deformation and Fracture of an Austenitic Stainless Steel," *J. Met.* 5(12), 28 (December 1983).

J. H. Schneibel, C. L. White, G. F. Petersen, and R. A. Padgett, "Creep Fracture in Austenitic Stainless Steels Containing Antimony or Titanium," pp. 1-9 in *Metals/Materials Technology Series*, proceedings of 1984 ASM International Conference on New Developments in Stainless Steel Technology (in conjunction with ASM Metals Congress) held in Detroit on Sept. 17-20, 1984, American Society for Metals, Metals Park, Ohio, 1984.

J. H. Schneibel, C. L. White, and M. H. Yoo, "On the Improvement of Creep Strength and Ductility of Ni-20% Cr by Small Zirconium Additions," *Metall. Trans. A* 16A, 651-60 (April 1985).

J. L. Scott et al., "The Trio-01 Experiment: In-Situ Tritium Recovery Results," *J. Nucl. Mater.* 122&123, 890-95 (1984).

J. L. Scott et al., *The Trio Experiment*, ANL-84-55, Argonne National Laboratory, Argonne, Ill., September 1984.

V. K. Sikka, *Characterization of Modified 9 Cr-1 Mo Steel Sand Castings*, ORNL/TM-9573, April 1985.

V. K. Sikka, *Properties of Electroslag Castings - Part I*, ORNL/TM-9301/P1, November 1984.

V. K. Sikka and M. D. Hart, *Characterization of Modified 9 Cr-1 Mo Steel Extruded Pipe*, ORNL-6154, April 1985.

V. K. Sikka and A. Mitchell, *Steel Castings by the Electroslag Casting Technique*, ORNL/TM-9115, October 1984.

V. K. Sikka and P. Patriarca, *Analysis of Weldment Mechanical Properties of Modified 9 Cr-1 Mo Steel*, ORNL/TM-9045, May 1984.

E. P. Simonen, N. M. Ghoniem, and N. H. Packan, "Pulsed Flux Effects on Radiation Damage," *J. Nucl. Mater.* 122&123, 391-401 (1984).

W. A. Simpson, Jr., and R. W. McClung, *Ultrasonic Characterization of Advanced Composite Flywheels*, ORNL/TM-9046, August 1984.

P. S. Sklad, "Swelling and Phase Instability in Neutron Irradiated Compositional Variants of Alloy D9," pp. 205-34 in *National Cladding/Duct Materials Development Program Quarterly Technical Progress Letter*, July-August-September 1979, TC-160-22, comp. J. L. Straalsund, Hanford Engineering Development Laboratory, Richland, Wash., 1979.

P. S. Sklad, P. Angelini, M. B. Lewis, and C. J. McHargue, "Microstructural Development of TiB₂ Ion Implanted with 1 MEV Nickel," pp. 407-12 in *Defect Properties and Processing of High-Technology Nonmetallic Materials*, proceedings of symposium held in Boston on Nov. 14-18, 1983, ed. J. H. Crawford, Jr., Y. Chen, and W. A. Sibley, Materials Research Society Symposia Proceedings, vol. 24, Elsevier, New York, 1984.

P. S. Sklad, P. Angelini, C. J. McHargue, and J. M. Williams, "Analytical Electron Microscopy of SiC Implanted with Cr Ions," pp. 416-17 in *Proceedings 42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, August 13-17, 1984*, ed. G. W. Bailey, San Francisco Press, San Francisco, 1984.

P. S. Sklad, P. Angelini, C. J. McHargue, and J. M. Williams, "Analytical Electron Microscopy of Surface Modified SiC," abstract, p. 25 in *Tennessee Valley Chapter 4th Annual Symposium and Equipment Exhibit*, program of meeting held in Knoxville, Tenn., on May 1-3, 1984, American Vacuum Society, New York, 1984.

P. S. Sklad and H. Schroeder, "The Effect of Implanted Helium on the Microstructure and Creep Properties of Ordered $(\text{Fe}_{0.4}\text{Ni}_{0.5})_3\text{V}$ Alloys," *J. Nucl. Mater.* 122&123, 709-14 (1984).

J. L. Snelgrove and G. L. Copeland, "Irradiation Testing of Full-Sized, Reduced-Enrichment Fuel Elements," pp. 139-47 in *Proceedings of the International Meeting on Development, Fabrication and Application of Reduced Enrichment Fuels for Research and Test Reactors, Argonne, Illinois, November 12-14, 1980*, ANL/RERTR/TM-3, CONF-801144, Reduced Enrichment Research and Test Reactor Program, Argonne National Laboratory, Argonne, Ill., August 1983.

J. L. Snelgrove, R. F. Domagala, T. C. Wiencek, and G. L. Copeland, "Fuel Development Activities of the U.S. RERTR Program," pp. 34-42 in *Proceedings of the International Meeting on Reduced Enrichment for Research and Test Reactors, October 24-27, 1983*, held in Tokai, Japan, JAERI-M 84-073, ed. K. Tsuchihashi, Japan Atomic Energy Research Institute, Tokai-mura, Japan, 1984.

C. J. Sparks, Jr., "X-Ray Microprobe Characterization of Materials: The Case for Undulators on Advanced Storage Rings," pp. 91-125 in *Major Facilities for Materials Research and Related Disciplines*, presentations to the Major Materials Facilities Committee, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, on March 17, 1984, Washington, D.C., National Academy Press, Washington, D.C., 1984.

J. A. Spitznagel, B. O. Hall, N. J. Doyle, R. Jayram, R. W. Wallace, J. R. Townsend, and M. Miller, "Effects of Nitrogen and Helium Ion Implantation on Uniaxial Tensile Properties of 316 SS Foils," pp. 597-601 in *Materials Research Society Symposium Proceedings*, vol. 24, Elsevier, New York, 1984.

J. Staunton, B. L. Gyorffy, A. J. Pindor, G. M. Stocks, and H. Winter, "The 'Disordered Local Moment' Picture of Itinerant Magnetism at Finite Temperatures," *J. Magn. Magn. Mater.* 45, 15-22 (1984).

W. J. Stelzman, R. G. Berggren, and T. N. Jones, Jr., *ORNL Characterization of Heavy-Section Steel Technology Program Plates 01, 02, and 03*, NUREG/CR-4092, ORNL/TM-9491, April 1985.

D. P. Stinton and R. L. Berger, *Calorimetric Examination of Hydrofracture Grouts*, ORNL/TM-9338, December 1984.

D. P. Stinton, W. J. Lackey, R. J. Lauf, and T. M. Besmann, "Fabrication of Ceramic-Ceramic Composites by Chemical Vapor Deposition," pp. 668-76 in *Proceedings of the 8th Annual Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, Florida, January 15-18, 1984*, ed. W. J. Smothers, The American Ceramic Society, Inc., Columbus, Ohio, 1984.

D. P. Stinton, E. W. McDaniel, and H. O. Weeren, "Characterization of Hydrofracture Grouts for Radionuclide Migration," pp. 448-55 in *Nuclear Waste Management*, proceedings of the Second International Symposium on Ceramics in Nuclear Waste Management held in Chicago on Apr. 24-27, 1983, *Advances in Ceramics*, vol. 8, ed. G. G. Wicks and W. A. Ross, American Ceramic Society, Columbus, Ohio, 1984.

G. M. Stocks, J. S. Faulkner, M. Boring, F. J. Pinski, and D. D. Johnson, "Abinitio Theory of the Electronic Structure of the Hume-Rothery Alloys," abstract, p. 12 in *114th TMS AIME Annual Meeting*, program of meeting held in New York, Feb. 24-28, 1985, The Metallurgical Society of AIME, New York, 1985.

G. M. Stocks, J. Wadsworth, and B. L. Gyorffy, "First Principles Theory of Fermi-Surface Driven Concentration Waves in $\text{Cu}_c\text{Pd}_{1-c}$ Alloys," pp. 15-17 in *Alloy Phase Diagrams*, proceedings of Symposium O, 1984 Fall Meeting of the Materials Research Society held in Boston on Nov. 29-30, 1984, Materials Research Society, Pittsburgh, 1984.

R. W. Swindeman, R. K. Nanstad, J. F. King, and W. J. Stelzman, *Effect of Tempering on the Strength and Toughness of 2 1/4 Cr-1 Mo Steel Weldments*, ORNL/TM-9307, October 1984.

R. W. Swindeman, R. D. Thomas, R. K. Nanstad, and C. J. Long, *Assessment of the Need for an Advanced High-Strength Chromium-Molybdenum Steel for Construction of Third-Generation Gasifier Pressure Vessels*, ORNL/TM-8873, October 1984.

Z. Szotek, B. L. Gyorffy, G. M. Stocks, and W. M. Temmerman, "Electron and Electron-Positron Momentum Distributions in Concentrated Random Alloys," *J. Phys. F* 14, 2571-99 (1984).

T. N. Tieg and A. J. Moorhead, *Dispersed-Metal-Toughened Alumina*, ORNL/TM-9518, February 1985.

P. F. Tortorelli and J. H. DeVan, "Corrosion of an Fe-12 Cr-1 Mo VW Steel in Thermally-Convective Lithium," pp. 215-21 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies* held in Snowbird, Utah, on June 19-23, 1983, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa. 1984.

P. F. Tortorelli and J. H. DeVan, "Effects of a Flowing Lithium Environment on the Surface Morphology and Composition of Austenitic Stainless Steel," pp. 213-26 in *Microstructural Science*, vol. 12, proceedings of Sixteenth Annual Technical Meeting of the International Metallographic Society, Calgary, Canada, Jul. 27, 1983, ed. D. O. Northwood, W. E. White, and G. F. Vander Voort, International Metallographic Society, Columbus, Ohio, and American Society for Metals, Metals Park, Ohio, 1985.

P. F. Tortorelli and J. H. DeVan, "Mass Transfer Behavior of a Modified Austenitic Stainless Steel in Lithium," *J. Nucl. Mater.* 122&123, 1258-63 (1984).

P. F. Tortorelli and J. H. DeVan, "Surface Analysis of Ferrous Alloys Exposed to Static Pb-17 at. % Li," *J. Nucl. Mater.* 122&123, 1264 (1984).

H. Trinkaus and W. G. Wolfer, "Conditions for Dislocation Loop Punching by Helium Bubbles," *J. Nucl. Mater.* 122&123, 552-57 (1984).

J. M. Vitek and S. A. David, "Metastable Equilibrium of Ferrite in Type 308 Stainless Steel," *Scr. Metall.* 19(1), 23-26 (1985).

J. M. Vitek and S. A. David, "The Solidification and Aging Behavior of Types 308 and 308CRE Stainless Steel Welds," *Weld J.* (Miami) 63(8), 246-53-s (August 1984).

J. M. Vitek, S. A. David, W. H. Smith, and R. W. Reed, *Solidification and Aging Behavior of Types 308 and 308CRE Stainless Steel Welds*, ORNL/TM-9086, August 1984.

J. M. Vitek and R. L. Klueh, "Microstructure of 9 Cr-1 MoVNb Steel Irradiated to 36 dpa at Elevated Temperatures in HFIR," *J. Nucl. Mater.* 122&123, 254-59 (1984).

J. M. Vitek and R. L. Klueh, "Microstructure of HFIR-Irradiated 12 Cr-1 MoVW Ferritic Steel," pp. 551-58 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies* held in Snowbird, Utah, on June 19-23, 1983, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

J. Wadsworth, B. L. Gyorffy, and G. M. Stocks, "First Principles Calculations of Short-Range Order Diffuse Scattering: Fermi-Surface Driven Concentration Waves in $\text{Cu}_c\text{Pd}_{1-c}$ Alloys," pp. 183-98 in *High-Temperature Alloys: Theory and Design*, proceedings of conference sponsored by Alloy Phases Committee of the Metallurgical Society of AIME and the Metals and Ceramics Division, Oak Ridge National Laboratory, held in Bethesda, Md., Apr. 9-11, 1984, ed. J. O. Stiegler, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

G. C. Wei and P. F. Becher, "Improvements in Mechanical Properties in SiC by the Addition of TiC Particles," *J. Am. Ceram. Soc.* 67(8), 571-74 (August 1984).

G. C. Wei, C. R. Kennedy, and L. A. Harris, "Synthesis of Sinterable SiC Powders by Carbothermic Reduction of Gel-Derived Precursors and Pyrolysis of Polycarbosilane," *Am. Ceram. Soc. Bull.* 63(8), 1054-61 (August 1984).

G. C. Wei and J. M. Robbins, "Carbon-Bonded Carbon Fiber Insulation for Radioisotope Space Power Systems," *Am. Ceram. Soc. Bull.* 64(5), 691-99 (1985).

G. C. Wei and C. L. White, "High Temperature Behavior of Pressureless Sintered SiC in a Steel Soaking Pit Environment," *Am. Ceram. Soc. Bull.* 63(7), 890-93 (July 1984).

J. R. Weir, Jr., "Role of Materials: Priorities," p. 5 in *ASM Conference on Materials for Future Energy Systems*, proceedings of meeting held in Washington, DC, on May 1-3, 1984, sponsored by ASM Technical Divisions Board in cooperation with U.S. Department of Energy, National Materials Advisory Board, and White House Office of Science and Technology Policy, American Society for Metals, Metals Park, Ohio, 1984.

J. R. Weir, Jr., J. E. Cunningham, and Irene Brogden, *Metals and Ceramics Division Progress Report for Period Ending June 30, 1984*, ORNL-6084, September 1984.

C. L. White, R. E. Clausing, and L. Heatherly, "The Effect of Trace Element Additions on the Grain Boundary Composition of Ir+0.3% W Alloys," p. 303 in *Residuals, Additives, and Materials Properties*, proceedings of a Joint Conference by the National Physical Laboratory, The Metals Society, and The Royal Society held in London on May 15-17, 1978, The Royal Society, London, 1980.

C. L. White, R. Dimas, and W. Losch, "High-Temperature Specimen Holder for Use with the PHI Model 2100 Specimen Introduction/Reaction Chamber," *Rev. Sci. Instrum.* 55(7), 1171-72 (July 1984).

C. L. White, R. A. Padgett, and C. T. Liu, "Surface and Grain Boundary Segregation in Relation to Intergranular Fracture: Boron and Sulfur in Ni₃Al," *Scr. Metall.* 18, 1417-20 (1984).

C. W. White, G. C. Farlow, C. J. McHargue, P. S. Sklad, P. Angelini, and B. R. Appleton, "Formation of Amorphous Layers in Al₂O₃ by Ion Implantation," *Nucl. Instrum. Methods Phys. Res. B* 7(8), 473-78 (1985).

C. W. White, G. C. Farlow, H. Naramoto, C. J. McHargue, and B. R. Appleton, "Modification of the Near-Surface Region of Al_2O_3 by Ion Implantation," pp. 163-72 in *Defect Properties and Processing of High-Technology Nonmetallic Materials*, proceedings of symposium held in Boston on Nov. 14-18, 1983, ed. J. H. Crawford, Jr., Y. Chen, and W. A. Sibley, Materials Research Society Symposia Proceedings, vol. 24, Elsevier, New York, 1984.

F. W. Wiffen, comp., *Alloy Development for Irradiation Performance Semiannual Progress Report for Period Ending March 31, 1984*, DOE/ER-0045/12, July 1984.

F. W. Wiffen, comp., *Alloy Development for Irradiation Performance Semiannual Progress Report for Period Ending September 30, 1984*, DOE/ER-0045/13, March 1985.

F. W. Wiffen, "Effects of Irradiation on Properties of Refractory Alloys with Emphasis on Space Power Reactor Applications," pp. 252-71 in *Refractory Alloy Technology for Space Nuclear Power Applications*, proceedings of symposium held in Oak Ridge, Tenn., on Aug. 10-11, 1983, CONF-8308130 (DE84001745), ed. R. H. Cooper, Jr., and E. E. Hoffman, Technical Information Center, U.S. Department of Energy, Oak Ridge, Tenn., January 1984.

F. W. Wiffen and R. T. Santoro, "Control of Activation Levels to Simplify Waste Management of Fusion Reactor Ferritic Steel Components," pp. 195-200 in *Proceedings of Topical Conference on Ferritic Alloys for Use in Nuclear Energy Technologies, Snowbird, Utah, June 19-23, 1983*, ed. J. W. Davis and D. J. Michel, The Metallurgical Society of AIME, Warrendale, Pa., 1984.

F. W. Wiffen, T. C. Reuther, and R. E. Gold, "Copper and Copper Alloys for Fusion Reactor Applications: Summary Report of a DOE-OFE Workshop," *J. Nucl. Mater.* 122&123, 799-801 (1984).

R. K. Williams, P. F. Becher, and C. B. Finch, "Study of the Kondo Effect and Intrinsic Electrical Conduction in Titanium Diboride," *J. Appl. Phys.* 56(8), 2295-2302 (October 1984).

R. K. Williams, R. S. Graves, and D. L. McElroy, "Thermal Conductivity of Cr_2O_3 in the Vicinity of the Neel Transition," *J. Am. Ceram. Soc.* 67(7), C-151-52 (July 1984).

R. O. Williams, "Orthogonal Coordinates for Systems of Many Components," *Metall. Trans. A* 16A, 929-33 (May 1985).

H. L. Yakel, "Crystal Structures of Stable and Metastable Iron-Containing Carbides," *Int. Met. Rev.* 30(1), 17-40 (1985).

H. L. Yakel, "Optimizing Estimates of Long-Range-Order Parameters with Anomalous Bragg X-Ray Scattering Data," p. 49 in *11th Annual User's Group Meeting, Stanford Synchrotron Radiation Laboratory*, held in Stanford, California, on Oct. 25-26, 1984, SSRL Report No. 84/06, Stanford University, 1984.

M. H. Yoo, C. L. White, and H. Trinkaus, *Interfacial Segregation and Fracture*, ORNL/TM-9016, March 1985.

C. S. Yust and F. J. Carignan, "Observations on the Sliding Wear of Ceramics," *ASLE Trans.* 28(2), 245-52 (1984).

C. S. Yust and C. J. McHargue, "Microstructure and Mechanical Properties of Ion-Implanted Ceramics," pp. 533-47 in *Emergent Process Methods for High-Technology Ceramics*, proceedings of 19th University Conference on Ceramic Science held in Raleigh, N.C., on Nov. 8-10, 1982, ed. R. F. Davis, H. Palmour III, and R. L. Porter, Materials Science Research, vol. 17, Plenum Press, New York, 1984.

S. J. Zinkle, R. A. Dodd, G. L. Kulcinski, and K. Farrell, "Helium Bubble Formation in Cu, Ni and Cu-Ni Alloys," *J. Nucl. Mater.* 117, 213-17 (1983).

Appendix H

PRESENTATIONS AT TECHNICAL MEETINGS

Compiled by Faye Roseberry

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

D. Nicholson,* L. Schwartz, A. Bansil, and R. Prasad, "Electronic Structure Calculations in Amorphous Cu-Zr Alloys"

2nd International Conference on Plastic Deformation in Ceramics, Pennsylvania State University, University Park, Pennsylvania, July 20-22, 1983:

R. F. Davis,* C. H. Carter, Jr., S. Chevacharoenkul, and J. Bentley, "The Occurance and Behavior of Dislocations During Plastic Deformation of Selected Transition Metal and Silicon Carbides"

Third Topical Meeting of Fusion Reactor Materials, Albuquerque, New Mexico, September 19-22, 1983:

R. G. Clemmer,* P. A. Finn, M. C. Billone, B. Misra, R. M. Arons, R. B. Poeppel, F. F. Dyer, I. T. Dudley, L. C. Bate, E. D. Clemmer, J. L. Scott, J. S. Watson, and P. W. Fisher, "The Trio-01 Experiment: In Situ Tritium Recovery Results"

Meeting, American Society for Metals/Materials Science Division, Philadelphia, Pennsylvania, October 2-6, 1983:

R. W. Swindeman* and C. W. Houck, "Metallurgical Examinations of Type 304 Stainless Steel Tested at High Temperature"

American Physical Society Meeting, Detroit, Michigan, March 26-30, 1984:

A. Chowdhary, D. Nicholson,* and L. Schwartz, "Electronic Structure of Amorphous NiP and CoP Alloys"

The Metallurgical Society of AIME Conference on High-Temperature Alloys: Theory and Design, Bethesda, Maryland, April 9-11, 1984:

B. L. Gyorffy, J. B. Staunton, and G. M. Stocks,* "Ferromagnetism in Metals at Finite Temperatures"

*Speaker.

Annual Meeting of the American Ceramic Society, Pittsburgh, Pennsylvania, April 29-May 3, 1984:

D. R. Johnson, A. C. Schaffhauser, R. B. Schulz,* V. J. Tennery, and E. L. Long, Jr., "The Ceramic Technology for Advanced Heat Engines Project"

American Society for Metals Conference on Materials for Energy Systems, Washington, D.C., May 1-3, 1984:

E. E. Bloom* and D. L. Smith, "Structural Materials for Fusion Reactor Blanket Systems"

Seminar, University of Tennessee, Knoxville, May 15, 1984:

J. M. Vitek, "Tempering Behavior of Ferritic Steel"

Carbon 84 Seminar organized by le Groupe Francais d'Etude des Carbones, Bordeaux, France, July 2-6, 1984:

C. R. Kennedy, G. B. Engle,* R. J. Price, and E. G. Morris, "Correlation Between Tensile Strength and Sonic Attenuation in a Structural Graphite"

NRC Office of Nuclear Regulatory Research Review of Progress in Quantitative NDE, University of California, San Diego, La Jolla, California, July 8-13, 1984:

C. V. Dodd, C. D. Cox, and W. E. Deeds,* "Experimental Verification of Eddy-Current Flaw Theory"

Seminar, Karlsruhe Nuclear Research Center, Federal Republic of Germany, July 9, 1984:

N. H. Packan, "Pulsed Dual-Ion Irradiations of Stainless Steels"

Conference on Ceramic Substrates, Cornell University, Ithaca, New York, July 15-18, 1984:

A. Bleier, "Effects of Powder Surface Chemistry on the Fabrication of Ceramic Thin Films"

American Association for Crystal Growth Meeting, Atlantic City, New Jersey, July 15-20, 1984:

G. W. Clark, "Eutectic-Like Solidification in Metal Oxide-Metal Diboride Systems"

Fourth Analytical Electron Microscopy Conference, Lehigh University, Bethlehem, Pennsylvania, July 16-20, 1984:

M. G. Burke,* M. K. Miller, S. S. Brenner, and W. A. Soffa, "A Combined AEM/FIM Study of Precipitation in an Fe-25 at. % Be Alloy"

E. A. Kenik* and P. J. Maziasz, "Application of Extraction Replicas and Analytical Electron Microscopy to Precipitate Phase Studies"

M. K. Miller, M. G. Burke,* S. S. Brenner, and W. A. Soffa,
"A TEM/FIM Study of Modulated Microstructures in the Fe-Be System"

P. S. Sklad,* J. Bentley, P. Angelini, and G. L. Lehman, "Reliability
of the Quantification of EELS Measurements"

J. M. Vitek (presented by D. Williams), "An EDS Round-Robin Evaluation
of Type 308 Austenitic Stainless Steel"

Fourth Analytical Electron Microscopy Workshop, Lehigh University,
Bethlehem, Pennsylvania, July 16-20, 1984:

P. Angelini* and J. Bentley, "Thermal Expansion Coefficient Determination
by CBED"

J. Bentley, "The Utility of Replica Techniques for X-Ray Microanalysis
of Second Phase Particles"

J. Bentley*, P. Angelini, and P. S. Sklad, "Secondary Fluorescence
Effects of X-Ray Microanalysis"

J. Bentley, G. L. Lehman*, and A. T. Fisher, "Structural Characterization
by Intensity Measurements of Electron Diffraction Patterns"

A. G. Dhere*, P. J. Reucroft, R. J. De Angelis, and J. Bentley,
"Characterization of Supported Metal Catalysts by Imaging, Microdiffraction
and Microanalysis Techniques"

19th Annual Microbeam Analysis Society Meeting and Fourth Analytical
Electron Microscopy Workshop, Bethlehem, Pennsylvania, July 16-20, 1984:

P. Angelini* and J. Bentley, "Thermal Expansion Coefficient Determination
by Convergent Beam Electron Diffraction"

Polymers, Ceramics, and Other Insulators Session at Ion Beam Modification
of Materials Meeting, Cornell University, Ithaca, New York, July 16-20,
1984:

G. C. Farlow,* C. W. White, C. J. McHargue, and B. R. Appleton,
"Annealing of Implanted Al_2O_3 in a Reducing Environment"

M. B. Lewis, "Long-Range Recoil Extension of Heavy Ion Damage in
Ceramics"

C. W. White,* G. C. Farlow, C. J. McHargue, P. S. Sklad, P. Angelini,
and B. R. Appleton, "Formation of Amorphous Layers in Al_2O_3 by Ion
Implantation"

J. M. Williams,* B. R. Appleton, C. J. McHargue, P. S. Sklad,
G. M. Begun, P. Angelini, and R. F. Davis, "Ion Implantation Effects
in SiC"

31st International Field Emission Symposium, Paris, France, July 16-20,
1984:

P. P. Camus, W. A. Soffa, S. S. Brenner, and M. K. Miller,*
"Quantification of Interconnected Microstructures by FIM"

M. K. Miller, "Imaging Atom Probe Computer Experiments"

M. K. Miller,* J. Bentley, S. S. Brenner, and J. A. Spitznagel, "Long Term Thermal Aging of Type CF 8 Stainless Steel"

M. K. Miller,* M. G. Burke, and S. S. Brenner, "Morphological Interpretation of Modulated Microstructures"

Seminar, Martin Marietta Laboratory, Baltimore, Maryland, July 17, 1984:

P. F. Becher, "Toughening Processes in Ceramic Composites"

A. J. Moorhead, "Some Research Activities of the Ceramic Technology Group"

J. O. Stiegler, "An Introduction to the Metals and Ceramics Division"

17th Annual Meeting of International Metallographic Society, Philadelphia, Pennsylvania, July 17-18, 1984:

R. J. Gray* and C. W. Houck, "Metallurgical Examinations of a Fragmented Blank Firing Adapter and Associated Components from an M-16 Rifle"

J. R. Keiser* and P. J. Ficalora, "Effects of the Impact of Small Hard Spheres on Ductile Metals"

P. F. Tortorelli,* T. J. Henson, J. R. Mayotte, and J. H. DeVan, "Metallographic Evaluation of the Reactions Between Boronated Graphite and Fe-Ni-Cr Alloys"

Ninth International Conference on Atomic Physics, Seattle, Washington, July 23-27, 1984:

G. B. Armen,* M. H. Chen, B. Craseman, J. C. Levin, G. S. Brown, and G. E. Ice, "Threshold M-Shell Excitation Accompanying K Ionization of Argon"

J. C. Levin,* G. B. Armen, M. H. Chen, B. Craseman, G. E. Ice, and G. S. Brown, "Measurements of Post-Collision Interaction in Auger Decay of Deep Hole States"

Workshop at Metal Properties Council Subcommittee 1 Meeting, Cornell University, Ithaca, New York, July 24-25, 1984:

R. W. Swindeman, "Status of DOE Sponsored Work to Evaluate High Strength 3 Cr-Mo Alloys"

Seminar, Oulu University, Oulu, Finland, July 26, 1984:

J. M. Vitek, "Welding of Austenitic Stainless Steels"

Seminar, Saclay Nuclear Research Center, Paris, France, July 26, 1984:

N. H. Packan, "Pulsed Dual-Ion Irradiations of Stainless Steels"

Gordon Research Conference on Frontiers of Science, New London, New Hampshire, July 29-Aug. 3, 1984:

P. F. Becher, "Toughening Effects in SiC Whisker Reinforced Oxides"

Second Conference in Series on Characterization of Ceramics and Glasses, New York State College of Ceramics at Alfred University, Alfred, New York, July 30-Aug. 4, 1984:

S. Baik,* D. E. Fowler, R. Raj, and J. M. Blakely, "Auger Spectroscopy and Leed Studies of Surface Segregation in Doped Sapphire"

W. C. Hasz and A. Bleier,* "Surface Reactivity of Silica and Alumina Ceramic Powders"

Seminar, Sandvik, Inc., Sandviken, Sweden, August 2, 1984:

J. M. Vitek, "Ferritic Steel Research for Fusion Reactor Applications"

International Union on Crystallography 13th Congress and General Assembly, Hamburg, Federal Republic of Germany, August 9-18, 1984:

H. L. Yakel, "Anomalous Scattering Studies of Average Distribution Parameters in Sigma and Tau Phases"

Electron Microscopy Society of America 42d Annual Meeting, Detroit, Michigan, August 13-17, 1984:

P. Angelini* and J. Bentley, "Secondary Fluorescence Effects on X-Ray Microanalysis"

J. Bentley* and P. Angelini, "X-Ray Microanalysis of Ion-Implantation Profiles in Backthinned Specimens"

C. K. H. DuBose, "Safety in the Materials Science Microscopy Laboratory"

J. A. Horton,* A. DasGupta, and C. T. Liu, "Disordering Process in an L1₂ Ordered Alloy"

L. L. Horton, "Experimental Determination of the Critical Cavity Radius in Fe-10% Cr for Ion Irradiation"

R. J. Lauf, "Irradiation Performance of Pyrolytic Silicon Carbide Coatings on Fissile Fuel Particles"

P. S. Sklad,* P. Angelini, C. J. McHargue, and J. M. Williams, "Analytical Electron Microscopy of SiC Implanted with Cr Ions"

Eighth European Congress on Electron Microscopy, Budapest, Hungary, August 13-18, 1984:

J. M. Vitek, "Round Robin EDS Evaluation of Fully Austenitic Stainless Steel"

American Council for an Energy Efficient Economy 1984 Summer Study on Energy Efficiency in Buildings, Santa Cruz, California, August 14-22, 1984:

T. S. Lundy, "National Program Planning: Philosophy and Example"

Gordon Research Conference on Quantum Solids, Wolfeboro, New Hampshire, August 15-19, 1983:

B. L. Gyorffy,* J. Kollar, A. J. Pindor, J. Staunton, G. M. Stocks, and H. Winter, "First Principles Theory of Magnetic Phase Transitions in Metal"

17th International Conference on Low Temperature Physics, Karlsruhe, Federal Republic of Germany, August 15-22, 1984:

H. R. Kershner, D. K. Christen, A. DasGupta, S. T. Sekula, B. C. Cai and Y. T. Chou, "Flux-Line Pinning by the Grain Boundary in Niobium Bicrystals"

Seminar, Shanghai Jiao Tong University, Shanghai, China, August 23, 1984:

C. T. Liu, "Design of Ordered Intermetallics"

Fifth RISO International Symposium on Metallurgy and Materials Sciences, RISO National Laboratory, Roskilde, Denmark, Sept. 3-7, 1984:

M. H. Yoo,* J. C. Ogle, J. H. Schneibel, and R. W. Swindeman, "SANS and TEM Studies of Carbide Precipitation and Creep Damage in Type 304 Stainless Steel"

Fifth International Conference on Rapidly Quenched Metals, Würzburg, Federal Republic of Germany, September 3-7, 1984:

S. A. David* and J. M. Vitek, "Microstructure of Rapidly Quenched 308 Stainless Steel Weld Filler Metals and Its Implications on Rapid Solidification Processes"

D. M. Kroeger,* C. C. Koch, C. G. McKamey, and J. O. Scarbrough, "A Study of Temper Embrittlement in an Iron-Based Metallic Glass"

Meeting of American Society for Metals Ark-La-Tex Chapter, Arcadia, Louisiana, September 4, 1984:

G. M. Slaughter, "Materials R&D for Energy Applications"

Fifth International Conference on Titanium, Munich, Federal Republic of Germany, September 10-14, 1984:

H. Inouye* and S. A. David, "Boron-Induced Toughness Loss in Ti-6 Al-2 Nb-1 Ta-0.8 Mo"

Meeting of American Society for Nondestructive Testing Local Section, Charlotte, North Carolina, September 13, 1984:

J. H. Smith, "Structure of the American Society for Nondestructive Testing"

42d Annual Meeting of the Electron Microscopy Society of America, Detroit, Michigan, September 13-17, 1984:

P. J. Maziasz, "Molybdenum Solubility Differences in MC Phases Formed in Titanium and Niobium Modified Austenitic Stainless Steels Determined Using AEM"

1984 American Society for Metals Congress, Detroit, Michigan, September 16-21, 1984:

W. R. Corwin,* R. K. Nanstad, and R. G. Berggren, "Fracture Behavior of Type 308/309 Stainless Steel Weld Overlay Cladding"

G. M. Goodwin,* C. P. Haltom, and P. A. Sanger, "Unintentional Carburizing Treatment Improves a Superconductor"

J. H. Schneibel,* C. L. White, G. F. Peterson, and R. A. Padgett, "Creep Fracture in an Austenitic Stainless Steel Containing Titanium and/or Antimony"

1984 International Conference on New Developments in Stainless Steel Technology, Detroit, Michigan, September 17-20, 1984:

J. H. Schneibel,* C. L. White, G. F. Petersen, and R. A. Padgett, "Creep Fracture in an Austenitic Stainless Steel Containing Titanium and/or Antimony"

International Conference on Surface Modification of Metals by Ion Beams, University of Heidelberg, Federal Republic of Germany, September 17-21, 1984:

C. J. McHargue,* G. C. Farlow, C. W. White, J. M. Williams, P. Angelini, and G. M. Begun, "The Amorphization of Ceramics by Ion Beams"

C. J. McHargue,* J. M. Williams, M. B. Lewis, and B. R. Appleton, "The Reactivity of Ion Implanted SiC"

1984 Fall Meeting of The Metallurgical Society of AIME, Detroit, Michigan, September 17-21, 1984:

E. A. Kenik, "HVEM In Situ Studies of Strain Localization in Al-Li Alloys"

L. Martinez* and J. H. Schneibel, "On the Measurement of Surface Free Energies of Solids"

Ninth European Conference on Thermophysical Properties, Manchester, United Kingdom, September 17-21, 1984:

D. L. McElroy,* R. S. Graves, D. W. Yarbrough, and T. W. Tong, "Non-Steady-State Behavior of Thermal Insulations"

Seminar, Martin Marietta Laboratories, Baltimore, Maryland, September 19, 1984:

C. T. Liu, "Development of Nickel Aluminides for High-Temperature Structural Use"

Seminar, Alcoa Technical Center, Alcoa Center, Pennsylvania, September 20, 1984:

C. T. Liu, "Development of New-Generation Materials Based on Aluminides for High-Temperature Use"

Seminar, Physics Laboratory, University of Athens, Greece, September 21, 1984:

P. Angelini, "Analytical Electron Microscopy of Ion Implanted Al_2O_3 ,"

Second International Conference on the Science of Hard Materials, Rhodes, Greece, September 23-28, 1984:

P. Angelini,* P. F. Becher, J. Bentley, J. Brynestad, M. K. Ferber, C. B. Finch, and P. S. Sklad, "Processing and Microstructural Development in Liquid Phase Sintered and Pure TiB_2 Ceramics"

C. J. McHargue,* C. S. Yust, P. Angelini, P. S. Sklad, and M. B. Lewis, "The Surface Mechanical Properties and Wear Behavior of Ion Implanted TiB_2 ,"

Energy Conversion and Utilization Technologies Workshop on Production and Fabrication of Ordered Intermetallic Alloys, Oak Ridge, Tennessee, September 25-26, 1984:

C. T. Liu,* C. L. White, and J. A. Horton, "The Role of Boron Additions on Grain-Boundary Chemistry and Tensile Properties of Ni_3Al Containing 24 and 26 at. % Al"

Metallographic Meeting of the German Society of Metals, Neu-Ulm, Federal Republic of Germany, September 26-28, 1984:

R. J. Gray* and G. Petzow, "Metallography, Yesterday, Today, Tomorrow"

Seminar, Max-Planck-Institut, Stuttgart, Federal Republic of Germany, October 1, 1984:

P. Angelini, "Characterization and Properties of TiB_2 ,"

University of Tennessee Graduate Seminar, Knoxville, Tennessee, October 2, 1984:

R. O. Williams, "The Calculations of the Effects of Coherency on Phase Stability"

Electrochemical Society Meeting, New Orleans, Louisiana, October 7-12, 1984:

J. C. Griess, "Problems in Estimating Corrosion in Nuclear Waste Repositories"

Society for the Advancement of Material and Process Engineering National Technical Conference, Albuquerque, New Mexico, October 9-11, 1984:

W. P. Eatherly, "Thermal Conductance and Diffusivity in Fibrous Composite Materials"

National Bureau of Standards-U.S. Department of Energy Workshop on Materials at Low Temperatures, Vail, Colorado, October 14-17, 1984:

G. M. Goodwin, "Fracture Toughness of Austenitic Stainless Steel Weld Metal at 4 K"

International Meeting on Reduced Enrichment for Research and Test Reactors, Argonne National Laboratory, Argonne, Illinois, October 14-18, 1984:

G. L. Copeland,* G. L. Hofman, and J. L. Snelgrove, "Irradiation Performance of Low-Enriched Uranium Fuel Elements"

J. Gómez, R. Morando, E. E. Perez,* D. R. Giorsetti, G. L. Copeland, E. Hofmann, and J. L. Snelgrove, "Postirradiation Examination of High-U-Loaded Low-Enriched U_3O_8 , UAl_2 , and U_3Si Test Fuel Plates"

American Society for Metals Mohawk Valley Chapter Meeting, New Hartford, New York, October 16, 1984:

G. M. Slaughter, "Materials R&D for Energy Applications"

Air Force Museum Foundation Aluminide Meeting, Dayton, Ohio, October 16-17, 1984:

C. T. Liu* and J. A. Stefani, "Iron Aluminides with Titanium Diboride Dispersions"

National Research Council Workshop, Ottawa, Canada, October 17-18, 1984:

D. W. Yarbrough* and D. L. McElroy, "Analysis of Transient Measurements Obtained for Thermal Insulations with the ORNL Flat Tester" ;

American Society for Testing and Materials E9/E24 Workshop on Fundamental Questions and Critical Experiments on Fatigue, Arlington, Texas, October 18-20, 1984:

R. W. Swindeman* and C. R. Brinkman, "What Creep Cavitation Studies are Needed to Develop Stainless Steels Resistant to Time-Dependent Fatigue?"

12th Water Reactor Safety Research Information Meeting, National Bureau of Standards, Gaithersburg, Maryland, sponsored by the U.S. Nuclear Regulatory Commission, October 22-26, 1984:

R. G. Berggren,* J. J. McGowan, R. K. Nanstad, K. R. Thoms, and B. H. Menke, "Irradiation Effects in Low-Alloy Reactor Pressure Vessel Steels (Heavy-Section Steel Technology Program Series 4 and 5)"

W. R. Corwin,* R. G. Berggren, and R. K. Nanstad, "Fracture Properties of a Neutron-Irradiated Stainless Steel Submerged Arc Weld Cladding Overlay"

Seminar, Cabot Corporation, Kokomo, Indiana, October 23, 1984:

R. O. Williams, "The Effects of Alloying on the Formation of Ordered Phases in the Ni-Mo System"

Seminar, Metallurgical Engineering Department, University of Tennessee, Knoxville, Tennessee, October 23, 1984:

P. J. Maziasz, "Phase Identification Using Analytical Electron Microscopy"

Visit of T. Fuketa, Director, Office of Planning, Japan Atomic Energy Research Institute, Tokyo, to Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 23, 1984:

J. L. Scott, "Status of U.S./Japan Collaborative Testing in HFIR and ORR"

Seminar, University of Pittsburgh, Pittsburgh, Pennsylvania, October 25, 1984:

S. A. David, "Effect of Initial Microstructure on the Transformation Characteristics of Type 308 Stainless Steel Weld Filler Metal"

Stanford Synchrotron Radiation Laboratory 1984 Users Group Meeting, Stanford, California, October 26, 1984:

H. L. Yakel, "Optimizing Estimates of Long-Range Order Parameters with Anomalous Bragg X-Ray Scattering Data"

Seminar, Lockheed Research Laboratory, Palo Alto, California, October 26, 1984:

C. L. White, "Boron Segregation and Ductilization of Grain Boundaries in Ni₃Al"

American Ceramic Society Fall Meeting, San Francisco, California, October 28-31, 1984:

C. B. Finch,* S. Baik, A. Bleier, and P. F. Becher, "Processing and Sintering of Submicrometer TiB₂ Powders"

C. R. Kennedy, "The Thermal Expansion of Heavily Irradiated Graphite"

R. J. Lauf,* W. D. Bond, and R. K. Williams, "Microstructures and Properties of Sol-Gel ZnO Varistors"

T. N. Tiegs* and P. F. Becher, "SiC Whisker Reinforced Alumina"

C. L. White, "Study of Solute Segregation at Interfaces Using Auger Electron Spectroscopy"

Seminar, Max-Planck Institut, Stuttgart, Federal Republic of Germany, October 29, 1984:

J. M. Vitek, "Investigation of Ferrite Stability in Duplex Austenitic Steels Using Analytical Electron Microscopy (AEM)"

22nd Automotive Technology Development Contractors' Coordination Meeting, Society of Automotive Engineers, Dearborn, Michigan, Oct. 29-Nov. 2, 1984:

J. P. Hammond*, S. A. David, and J. J. Woodhouse, "Indirect Brazing of Structural Ceramics for Uncooled Diesels"

M. A. Janney, "Particulate Toughened Silicon Carbide"

D. R. Johnson,* A. C. Schaffhauser, and R. B. Schulz, "The Ceramic Technology for Advanced Heat Engines Program"

W. J. Lackey* and D. P. Stinton, "Ceramic Coatings for Heat Engine Materials"

A. J. Moorhead, "Direct Brazing of Structural Ceramics for Uncooled Diesels"

V. J. Tennerly*, M. K. Ferber, P. F. Becher, and S. B. Waters, "Characterization of the Fatigue and Slow Crack Growth Behavior of Partially Stabilized Zirconia Ceramics"

T. N. Tiegs* and P. F. Becher, "Particulate and Whisker Toughened Alumina Composites"

Practical Conference on Communication, University of Tennessee, Knoxville, Tennessee, November 2-3, 1984:

O. A. Nelson, "Technical Communications Employment - Observations and Recommendations"

1984 Fall Conference of the Society for Experimental Mechanics, Milwaukee, Wisconsin, November 4-7, 1984:

J. J. McGowan and R. K. Nanstad,* "A Direct Comparison of Unloading Compliance and Potential Drop Techniques in J-Integral Testing"

Seminars, Institute Laue Langevin, Grenoble, France, and Research Center, Fiat, Torino, Italy, November 5 and 9, 1984:

M. H. Yoo, "SANS and TEM Studies of Carbide Precipitation and Creep Damage in Type 304 Stainless Steel"

State University of New York, Stony Brook, Department of Materials Science and Engineering, November 6, 1984:

C. J. Sparks, Jr., "X-Ray Microprobe Characterization of Materials: The Case for Undulators on Advanced Storage Rings"

Birmingham American Society for Metals Chapter Meeting, Birmingham, Alabama, November 8, 1984:

G. n. Slaughter, "Brazing and Soldering Technology - Past, Present, and Future"

Conference on Application of Accelerators in Research and Industry, North Texas State University, Denton, Texas, November 12-14, 1984:

C. J. McHargue,* G. C. Farlow, C. W. White, B. R. Appleton, P. Angelini, and H. Naramoto, "The Structure and Properties of Ion-Implanted Al_2O_3 "

Meeting, Research Committee on Design Technology for Nuclear Fusion Reactors of the Atomic Energy Society of Japan, JAERI Headquarters, Tokyo, Japan, November 14, 1984:

F. W. Wiffen, "The United States Program to Develop and Qualify First Wall/Blanket Structural Materials for Fusion Reactors "

Seminar, Heavy Irradiation Project Committee, University of Tokyo, Japan, November 15, 1984:

F. W. Wiffen, "Status of the United States Fusion Reactor Materials Irradiation Effects Program"

Research and Development Department Meeting, Nuclear Systems Division, Kawasaki Heavy Industries, Ltd., Kawasaki Design Office, Tokyo, Japan, November 16, 1984:

F. W. Wiffen, "An Overview of the United States Program to Develop Fusion Reactor Structural Materials"

Seminar, University of Tennessee, Department of Metallurgical Engineering, Knoxville, Tennessee, November 20, 1984:

C. L. White, "Boron Segregation and Ductilization of Grain Boundaries in Ni_3Al "

Materials Research Society 1984 Fall Meeting, Boston, Massachusetts, November 26-30, 1984:

P. Angelini, J. Bentley, A. T. Fisher, J. A. Horton, Jr., E. A. Kenik,* G. L. Lehman, and P. S. Sklad, "Comparison of Performance of an Analytical Electron Microscope at 300 and 100 kV"

J. V. Cathcart, "The Oxidation of Ordered Nickel-Aluminum and Iron-Aluminum Alloys"

A. DasGupta,* J. A. Horton, and C. T. Liu, "The Disorder Phase Transformation in $(\text{Ni}_{70}\text{Fe}_{30})_3(\text{V}_{90-x}\text{Ti}_x\text{Al}_x\text{Ti}_2)$ Alloys With $0 \leq x \leq 80$ "

J. A. Horton,* A. DasGupta, and C. T. Liu, "Anisotropic APB Formation and Disorder Process in an Ll_2 Ordered Alloy"

J. A. Horton,* A. DasGupta, and C. T. Liu, "The Disorder Process in an Ll_2 Ordered Alloy"

H. Inouye, "Effects of D₀ Transitions on the Yield Behavior of Fe-1 Alloys"

H. Inouye, "Order-Disorder Transformation Effects on the Yield Behavior of Fe-Al Alloys"

C. T. Liu* and C. L. White, "Alloy Design of Nickel Aluminides Based on Ni_3Al "

M. L. Santella* and S. A. David, "Weldability of Ni_3Al -Type Aluminide Alloys"

G. M. Stocks,* A. P. Maclin, and W. M. Temmerman, "The Electronic Structure of Transition Metal Aluminides"

G. M. Stocks,* J. Wadsworth, and B. L. Gyorffy, "First Principles Approach to the Calculation of Short-Range Order in Metallic Alloys"

G. M. Stocks,* J. Wadsworth, and B. L. Gyorffy, "First Principles Theory of Fermi-Surface Driven Concentration Waves in $\text{Cu}_c\text{Pd}_{1-c}$ Alloys"

R. K. Williams,* R. S. Graves, F. J. Weaver, and D. L. McElroy, "Physical Properties of Ni_3Al Containing 24 and 25 Atomic Percent Al"

30th Annual Conference on Magnetism and Magnetic Materials, San Diego, California, American Institute of Physics/Magnetics Society of IEEE, November 27-30, 1984:

D. D. Johnson,* F. J. Pinski, and G. M. Stocks, "Self-Consistent Electronic Structure of Disordered $\text{Fe}_{0.65}\text{Ni}_{0.35}$ "

American Society for Testing and Materials Symposium on Steel Forgings, Williamsburg, Virginia, November 28-29, 1984:

A. Khare and V. K. Sikka,* "Mechanical Properties of Modified 9 Cr-1 Mo Steel Forging"

Seminar, University of Tokyo, Japan, November 30, 1984:

P. J. Maziasz, "Radiation-Induced Precipitation Under Neutron Irradiation and Its Sensitivity to Helium Content in Austenitic Stainless Steels"

Symposium on Thermal Insulation Materials and Systems, Dallas, Texas, December 2-6, 1984:

D. L. McElroy*, D. W. Yarbrough, and R. S. Graves, "The Thickness and Density of Loose-Fill Insulations After Installation In Residential Attics"

First International Conference on Fusion Reactor Materials, Tokyo, Japan, December 3-6, 1984:

P. J. Maziasz, "A Perspective on Present and Future Alloy Development Efforts on Austenitic Stainless Steels for Fusion Application"

J. L. Scott et al. (presented by C. E. Johnson, Argonne National Laboratory), "The TRIO Experiment"

J. L. Scott*, F. W. Clinard, Jr., and F. W. Wiffen, "Special Purpose Materials for Fusion Application"

F. W. Wiffen, "Materials Engineering for TFCX and Other Near-Term Fusion Reactors"

Second USA-Japan Superalloys Seminar, Shizuoka, Japan, December 6-12 and 21, 1984:

C. T. Liu, "Design of Ordered Intermetallic Alloys for High-Temperature Use"

ASME Winter Annual Meeting, New Orleans, Louisiana, December 7-10, 1984:

T. W. Tong*, D. L. McElroy, and D. W. Yarbrough, "Transient Conduction and Radiation Heat Transfer in Porous Thermal Insulations"

Seminar, Japan Atomic Energy Research Institute, Tokai-mura, Japan, December 10, 1984:

P. J. Maziasz, "Radiation-Induced Precipitation Under Neutron Irradiation and Its Sensitivity to Helium Content in Austenitic Stainless Steels"

Dislocations and Properties of Real Materials, The Royal Society of London, England, December 11-12, 1984:

M. H. Yoo, "Slip-Interface Interaction at Elevated Temperatures"

ASME Winter Annual Meeting, ASTM-ASME-MPC J-1 Committee Workshop on Strain Softening Alloy, New Orleans, Louisiana, December 12, 1984:

R. W. Swindeman, "Construction of Isochronous Strain Curves for 9 Cr-1 Mo-V-Nb Steel Considering Strain Softening"

Arizona State University Centennial Symposium on High-Resolution Electron Microscopy, Scottsdale, Arizona, January 7-11, 1985:

D. N. Braski* and J. V. Cathcart, "The Effect of Y_2O_3 Dispersoid in 80Ni-20Cr Alloy on the Early Stages of Oxidation at 1273K"

Seminar, University of Tennessee, Knoxville, Tennessee, January 8, 1985:

J. H. Schneibel* and G. F. Petersen, "The Influence of Impurities on Grain Boundary Sliding in Nickel"

2d Symposium on Space Nuclear Power Systems, Albuquerque, New Mexico, January 14-16, 1985:

M. L. Grossbeck* and F. W. Wiffen, "Swelling and Tensile Properties of EBR-II-Irradiated Tantalum Alloys for Space Reactor Applications"

R. L. Heestand*, D. O. Hobson, R. L. Ammon, and B. Marsh, "Recent Fabrication Experience with Niobium, Tantalum, and Tungsten Alloys"

J. A. Horak, "Load-Carrying Capabilities of Refractory Alloys for Space Reactor Power Applications"

9th Annual Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, Florida, January 20-23, 1985:

A. J. Caputo*, W. J. Lackey, and D. P. Stinton, "Development of a New, Faster Process for the Fabrication of Ceramic Fiber-Reinforced Ceramic Composites by Chemical Vapor Infiltration"

D. P. Stinton* and W. J. Lackey, "Simultaneous Chemical Vapor Deposition of SiC-Dispersed Phase Composites"

Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, Florida, January 20-24, 1985:

A. J. Caputo* and W. J. Lackey, "Continued Development of the Fabrication of Ceramic Fiber-Reinforced Ceramic Composites"

M. A. Janney, "Oxidation of SiC-Matrix Composites"

D. P. Stinton* and W. J. Lackey, "Simultaneous Chemical Vapor Deposition of SiC-Dispersed Phase Composites"

Seminar, The Advanced Composites Working Group, Cocoa Beach, Florida, NASA and DOD, January 24-25, 1985:

T. N. Tiegs* and P. F. Becher, "SiC Whisker Reinforced Ceramic Composites"

Seminar, University of California, Santa Barbara, California, January 27, 1985:

W. R. Corwin, "Does Irradiation Degrade the Structural Capability of the Stainless Steel Weld Clad Overlay on the Interior of a Reactor Pressure Vessel?"

Seminar, Stanford University, Stanford, California, January 28, 1985:

W. C. Oliver, "Ultra Low Load Hardness Testing"

Seminar, IBM, San Jose, California, January 29, 1985:

W. C. Oliver, "Ultra Low Load Hardness Testing"

Seminar, Hewlett Packard, San Jose, California, January 30, 1985:

W. C. Oliver, "Ultra Low Load Hardness Testing"

Seminar, University of Tennessee, Department of Nuclear Engineering, Knoxville, Tennessee, February 6, 1985:

R. W. McClung, "Survey of Nondestructive Testing and Applications"

Meeting, Cummins Diesel, Columbus, Indiana, February 11, 1985:

R. W. McClung, "The Development Program for Nondestructive Testing at the Oak Ridge National Laboratory"

12th Annual WATtec Energy Conference, Knoxville, Tennessee, February 12-15, 1985:

D. R. Johnson, "Ceramic Technology for Advanced Heat Engines"

A. J. Moorhead, "Direct Brazing of Structural Ceramics for Automotive Applications"

Meeting of the American Society for Metals, Savannah River Chapter, Aiken, South Carolina, February 14, 1985:

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

Seminar, University of Tennessee, Knoxville, Tennessee, February 19, 1985:

P. F. Becher, "Stress-Induced Phase Transformations Yield Toughened Ceramics"

Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, New York, February 24-28, 1985:

S. A. David* and V. P. Kujanpää, "Correlation Between Solidification Parameters and Weld Microstructure"

J. H. Schneibel* and L. Martinez, "On the Measurement of Surface Free Energies of Solids"

J. H. Schneibel,* L. Martinez, and C. L. White, "Comparison of Cavitation in Stainless Steels with Different Creep Ductilities"

G. M. Stocks,* J. S. Faulkner, M. Boring, F. J. Pinski, and D. D. Johnson, "Abinitio Theory of the Electronic Structure of the Hume-Rothery Alloys"

C. L. White, "Kinetic Mechanisms for S and Sb Segregation to Free Surfaces in Ni-1 wt % Sb at 700°C"

R. O. Williams, "The Role of Coherency in Understanding Long Period Superlattices"

Seminar, Kernforschungszentrum, Karlsruhe, Federal Republic of Germany, February 25, 1985:

J. M. Vitek, "Research at ORNL on Ferritic Steels for Fusion Reactor Applications"

Symposium on Noble Metal Alloys, New York, New York, February 25-27, 1985:

G. M. Stocks,* M. Boring, D. M. Nicholson, F. J. Pinski, D. D. Johnson, J. S. Faulkner, and B. L. Gyorffy, "Self-Consistent Electronic Structures of α -Phase Hume-Rothery Electron Compound Alloys $\text{Cu}_c\text{Zn}_{1-c}$, $\text{Cu}_c\text{Ga}_{1-c}$, and $\text{Cu}_c\text{Ge}_{1-c}$ "

Workshop, Electroslag Processing for Marine Applications, U.S. Naval Academy, Annapolis, Maryland, March 5-6, 1985:

R. R. Judkins* and V. K. Sikka, "Evaluation of Electroslag Castings"

Seminar, American Society for Metals Visiting Lecture Program, Bangalore, India, March 6, 1985:

S. A. David, "Welding and Weldability of Nickel-Iron Aluminides"

Seminar, Vacuumschmelze, Hanau, Federal Republic of Germany, March 6, 1985:

J. M. Vitek, "The Effect of Cooling Rate on the Structure of Austenitic Stainless Steels"

Seminar, Mannesmann Forschungsinstitute, Duisburg, Federal Republic of Germany, March 7, 1985:

J. M. Vitek, "Research at ORNL on Ferritic Steels for Fusion Reactor Applications"

Seminar, Kernforschungsanlage, Jülich, Federal Republic of Germany, March 8, 1985:

J. M. Vitek, "Research at ORNL on Ferritic Steels for Fusion Reactor Applications"

Seminar, American Society for Metals Visiting Lecture Program, Madras, India, March 11, 1985:

S. A. David, "Solidification Behavior, Microstructure and Modification of Austenitic Stainless Steel Weld Metal"

S. A. David,* D. N. Braski, and C. T. Liu, "Welding of Ductile Long-Range-Ordered Alloys"

Seminar, Quantum Chemistry and Solid-State Theory, Part II of 1985 Sanibel Symposia, sponsored by the University of Florida, St. Augustine, Florida, March 18-23, 1985:

J. S. Faulkner, "Electronic States in Disordered Solids, III. Applications to Materials Science"

Seminar, Arizona State University, Tempe, Arizona, March 21-26, 1985:

L. K. Mansur, "How Swelling Begins in Irradiated Metals (and What Can be Done About It)"

Seminar, Waste Management '85, sponsored by the University of Arizona, Tucson, Arizona, March 24-28, 1985:

D. P. Stinton* and R. L. Berger, "Calorimetric Examination of Hydrofracture Grouts"

American Physical Society Meeting, Baltimore, Maryland, March 25-29, 1985:

A. Al-Lehaibi, J. C. Swihart,* W. H. Butler, and F. J. Pinski, "Electron-Phonon Interaction Effects in Tantalum"

W. H. Butler, "Electron-Phonon Scattering Using the Coherent-Potential Approximation"

A. Chowdhary,* D. Nicholson, and L. Schwartz, "Electronic Structure of Amorphous Ni-B and Ni-P Alloys"

A. P. Maclin* and G. M. Stocks, "Electronic Structures of Aluminum-Rich $\text{Al}_c\text{Li}_{1-c}$ Alloys"

D. M. Nicholson* and G. M. Stocks, "Electronic Structure of $\text{Ni}_{1-x}\text{Mo}_x$ Alloys"

D. M. Nicholson,* G. M. Stocks, D. D. Johnson, F. J. Pinski, and B. L. Gyorffy, "Local Density Theory of Random Alloys"

G. S. Painter* and F. W. Averill, "The Total Energy Hypersurface and Force Field in Transition Metal Clusters as Calculated in the Local Spin Density Approximation"

G. M. Stocks and F. J. Pinski,* "Use of Integration in the Complex Energy Plane in Multiple Scattering Greens Function Methods: An Optimal Contour"

J. C. Swihart* and W. H. Butler, "Theory and Calculation of Electrical Conductivity in Random Alloys"

Corrosion 85, National Association of Corrosion Engineers, Boston, Massachusetts, March 25-29, 1985:

H. S. Hsu* and J. H. DeVan, "Thermodynamics of the Corrosion of Chromium in Molten Carbonates"

C. T. Liu* and J. V. Cathcart, "Ordered Intermetallic Alloys Based on Ni₃Al for High-Temperature Applications"

Seminar, Characterization of Chemically Processed Ceramics, Rutgers University, Piscataway, New Jersey, March 26, 1985:

A. Bleier, "Surface, Colloidal, and Chemical Properties of Ceramic Powders"

Seminar, University of California, Los Angeles, California, March 26-29, 1985:

L. K. Mansur, "How Swelling Begins in Irradiated Metals (and What Can be Done About It)"

Seminar, University of Connecticut, Storrs, Connecticut, March 27, 1985:

C. T. Liu, "Design of Polycrystalline Nickel Aluminides for Structural Uses"

Seminar, Cambridge University, CEBG, Berkley, England, April 1, 1985:

M. H. Yoo, "Interfacial Segregation and Fracture at Elevated Temperature"

IMOG Joining Subgroup Meeting, Los Alamos National Laboratory, Los Alamos, New Mexico, April 2-5, 1985:

G. M. Goodwin, "Hot Cracking of Austenitic Stainless Steels: The Debut of the 'SigmaJig'"

New Directions in X-Ray Scattering Workshop, Lawrence Livermore Laboratory, Asilomar, California, April 3-5, 1985:

G. E. Ice, "Experimental X-Ray Scattering Cross Sections for H₂ and Rare Atomic Gases"

American Ceramic Society, Northeast Section Meeting, Boston, Massachusetts, April 11, 1985:

C. J. McHargue, "Ion Beam Modification of Ceramics"

Seminar, Rice University, Houston, Texas, April 12-15, 1985:

W. C. Oliver, "Hardness Measurements With Indents As Shallow As 20 nm"

1985 American Society of Mechanical Engineers Conference on Wear of Materials, Vancouver, British Columbia, April 14-18, 1985:

W. C. Oliver, "The Wear Properties and Near Surface Hardness of Ion Implanted Ti and Ti-6Al-4V"

C. S. Yust* and F. J. Carignan, "Initial Stages of Dry Sliding Wear in PSZ"

Seminar, Universidade De Coimbra, Coimbra, Portugal, April 15-19, 1985:

D. W. Yarbrough,* D. L. McElroy, T. W. Tong, and J. K. Wood III,
"Analysis of Transient Thermal Measurements on Fibrous Insulations
Obtained with an Unguarded Flat Tester"

American Society for Metals, Columbia Chapter Meeting, Richland,
Washington, April 18, 1985:

G. M. Slaughter, "Materials R&D for Energy Applications"

American Society for Nondestructive Testing, Nashville, Tennessee,
Section Meeting, April 23, 1985:

J. H. Smith, "Ultrasonic Inspection of Welds"

66th Annual Meeting of the American Welding Society, Las Vegas, Nevada,
April 29-May 3, 1985:

G. M. Goodwin, "Fracture Toughness of Austenitic Stainless Steel Weld
Metal at 4K"

G. M. Goodwin* and R. K. Nanstad, "Effect of Temperature on the
Stress-Relaxation Response of a Pressure Vessel Steel Heat-Affected
Zone"

J. P. Hammond,* J. J. Woodhouse, and S. A. David, "Active Substrate
Process for Brazing Ceramics to Metals"

M. L. Santella* and S. A. David, "A Study of HAZ Cracking in Ductile
Aluminides"

Seminar, Materials Science and Engineering Department, University of
Tennessee, Knoxville, Tennessee, April 30, 1985:

M. K. Miller, "Atom Probe Field Ion Microscopy"

American Vacuum Society Meeting, Sheraton West, Knoxville, Tennessee,
April 30-May 2, 1985:

W. C. Oliver, "The Use of Ultra-Low Load Testing to Mechanically
Characterize Thin Films"

Seminar, University of Illinois, Urbana-Champaign, Illinois, May 3, 1985:

P. F. Becher, "Stress-Induced Phase Transformations Yield Toughened
Ceramics"

87th Annual Meeting of the American Ceramic Society, Cincinnati, Ohio,
May 5-9, 1985:

P. Angelini, C. B. Finch, P. F. Becher,* J. Bentley, and P. S. Sklad,
"Evaluation of Liquid Phase Sintering Mechanisms in TiB_2 -Ni Ceramics
by TEM and Electron Microprobe Analyses"

S. Baik,* P. Angelini, P. F. Becher, C. E. Bamberger, and J. Brynestad, "The Effect of Impurities on Sintering of Submicrometer TiB_2 Powders"

P. F. Becher,* G. Begun, S. B. Waters, W. H. Warwick, and M. K. Ferber, "Temperature Dependence of Fracture Toughness in MgO-PSZ and ZrO_2 (Y_2O_3) Toughened Alumina"

J. Cesarano,* I. A. Aksay, and A. Bleier, "Polyelectrolyte Adsorption on $\alpha\text{-Al}_2\text{O}_3$ and Aqueous Suspension Stability"

M. K. Ferber, S. D. Brown, and P. F. Becher,* "Temperature and Stress Dependence of Slow Crack Growth In Polycrystalline BeO "

M. A. Janney, "Carbothermal Synthesis of SiC Powders"

S. Spooner,* P. Angelini, P. F. Becher, A. Bleier, W. D. Bond, and J. Brynestad, "Investigation of the Synthesis and Processing of Submicron Ceramic Powders by TEM and Small Angle X-Ray Scattering (SAXS)"

D. P. Stinton* and W. J. Lackey, "Coating of Nicalon Fibers by CVD for Ceramic Composite Applications"

V. J. Tennery,* J. C. Ogle, and M. K. Ferber, "Role of Stress, Corrosion, Time, and Temperature on Strength of Alpha Silicon Carbide Ceramics"

Meeting of American Society for Metals, Richmond Chapter, Richmond, Virginia, May 14, 1985:

G. M. Slaughter, "Materials R&D for Energy Applications"

1985 American Petroleum Institute Midyear Refining Meeting, Kansas City, Missouri, May 14, 1985:

M. Jawad, V. K. Sikka,* and P. Patriarca, "Fabrication and Metallurgical Properties of Modified 9 Cr-1 Mo Steel"

Seminar, Auburn University, Auburn, Alabama, May 16, 1985:

V. K. Sikka (presented by C. R. Brinkman), "Development and Commercialization of New Alloys"

Seminar, Thomas J. Watson Research Center, IBM Corporation, Yorktown Heights, New York, May 21, 1985:

C. J. Sparks, Jr., "X-Ray Microprobe Characterization of Materials"

Symposium, American Association for the Advancement of Science, Los Angeles, California, May 29, 1985:

D. L. McElroy, "Building Insulations"

Meeting on Application of Ion Plating and Ion Implantation to Materials, Atlanta, Georgia, June 3-5, 1985:

C. J. McHargue,* G. C. Farlow, C. W. White, B. R. Appleton, J. M. Williams, P. S. Sklad, P. Angelini, and C. S. Yust, "Surface Property Modification of Ceramics by Ion Beams"

International CALPHAD Meeting, Massachusetts Institute of Technology, Cambridge, Massachusetts, June 10-14, 1985:

R. O. Williams, "The Effect of Ternary Additions on the Phase Stability in the Ni-Mo System"

Meeting of the American Nuclear Society, Boston, Massachusetts, June 9-12, 1985:

R. W. Conn and F. W. Wiffen,* "Fusion Materials Activation Characteristics as Related to Waste Disposal Requirements"

17th Carbon Conference, American Carbon Society, University of Kentucky, Lexington, Kentucky, June 16-21, 1985:

C. R. Kennedy* and M. T. Kehne, "The Effect of Preferred Orientation on the Fracture Toughness of Graphite"

C. R. Kennedy and M. T. Kehne,* "Fracture Toughness of Anisotropic Graphites"

Seminar, Department of Metallurgy, University of Wisconsin, Madison, Wisconsin, June 19, 1985:

J. P. Hammond and S. A. David,* "Active Substrate Process for Joining Ceramics to Metals"

4th International Conference on Fracture Mechanics of Ceramics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, June 19-21, 1985:

P. F. Becher,* T. N. Tiegs, J. C. Ogle, and W. H. Warwick, "Toughening of Ceramics by Whisker Reinforcement"

4th Annual Steam Generator NDE Workshop, Myrtle Beach, South Carolina, June 24-26, 1985:

C. V. Dodd, "Eddy-Current Research Programs at Oak Ridge National Laboratory"

Symposium on Surface and Colloid Science in Computer Technology, part of the 5th International Conference on Surface and Colloid Science, Clarkson College of Technology, Potsdam, New York, June 24-28, 1985:

A. Bleier* and P. Angelini, "Synthesis and Colloidal Properties of Uniform Monoclinic Zirconia"

J. Cesarano, I. A. Aksay, and A. Bleier,* "Interaction of Polymethacrylic Acid with α -Al₂O₃ in Aqueous Suspension"

Workshop on the Relation Between Mechanical Properties and Microstructure Under Fusion Irradiation Conditions, Ebeltoft, Denmark, June 27-July 2, 1985:

M. L. Grossbeck and J. A. Horak (presented by N. H. Packan), "Tensile Properties of V 15Cr 5Ti Following Neutron Irradiation and Helium Implantation"

N. H. Packan, "The Effect of Pulsed Irradiation on Microstructural Evolution"

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