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OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

Metals and Ceramics Division Annual Progress Report for Period Ending June 30, 1980

METALS and CERAMICS — ENERGY — RESEARCH — DEVELOPMENT — OAK RIDGE NATIONAL LABORATORY

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METALS AND CERAMICS DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING JUNE 30, 1980

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for the
DEPARTMENT OF ENERGY

Contents

Foreword

This progress report covers the research and development activities of the Metals and Ceramics Division for the 12-month period July 1, 1979, through June 30, 1980. In keeping with past custom, the format of the report follows rather closely the organizational structure of the Division. Short summaries of technical work in progress in the various functional units are grouped and presented in four parts. Part 1 deals with the technical activities of the Engineering Materials Section, Part 2 with the Fuels and Processes Section, Part 3 with the Materials Science Section, and Part 4 with technical support rendered by the Metallographic Laboratory. Two relatively new activities appear in the last two parts of the report. Part 5 describes the lead missions and technology centers of national scope assigned to ORNL and in which materials people play a dominant management role, while Part 6 presents the status of specialized facilities and equipment operated in a users mode. The Division promotes collaborative and joint research with the university community and the industrial sector of the United States by making such facilities available for advancing materials science and technology on a broad front. Background information on the level and source of financial support, personnel, organizational structure, seminar program, honors and awards, 1980 advisory committee, technical publications, and oral presentations at technical meetings appear in appendices in summary form.

The past year was marked by substantial growth in financial support and diversification of research and development operations conducted in the Division. Operating funds rose steadily each month and on July 1, 1980, stood at a level 36% higher than at the beginning of the fiscal year. However, most of the increased support came in the form of pass-through money to defray subcontract costs and, hence, had little impact on in-house research. On the other hand, subcontract work rose dramatically from \$1.8 M to a level of \$8.8 M. The shift from nuclear to nonnuclear activity continued at an accelerated pace. Funding for fission-oriented projects dropped from 36 to 28% of the total effort. Offsetting increases for additional research were registered in the areas of radioactive waste treatment for storage, space energy systems, and NRC licensing. On overall balance, the Division remains in sound financial condition and continues to broaden its base of research and development.

To cope with the evolving change in direction and thrust of effort, two new functional groups have been established in the Materials Science Section. A new Structural Ceramics group was constituted to study structure-property relationships of ceramics materials for high-temperature applications. The other, entitled the Alloying Behavior and Design Group, will focus on understanding of alloying effects with the intent of upgrading the stability and performance of materials at elevated temperature. In addition, the Division was assigned a new Laboratory-lead mission in the area of materials for Energy Conservation and Utilization Technology (ECUT), as well as a technical lead role on materials for the Space Energy Systems program. More recently, the Division has initiated an assessment of research needs and opportunities in the field of materials substitutability.

The 30-m small-angle neutron scattering (SANS) research facility was successfully placed in operation on schedule. The first beam, which was achieved in December, had measured flux incident on the sample of 4×10^8 n/m^{2}s.

Previous reports issued in the series are listed on the next page.

Reports previously issued in this series are as follows:

ORNL-28	Period Ending March 1, 1948
ORNL-69	Period Ending May 31, 1948
ORNL-407	Period Ending July 31, 1949
ORNL-511	Period Ending October 31, 1949
ORNL-583	Period Ending January 31, 1950
ORNL-754	Period Ending April 30, 1950
ORNL-827	Period Ending July 31, 1950
ORNL-910	Period Ending October 31, 1950
ORNL-987	Period Ending January 31, 1951
ORNL-1033	Period Ending April 30, 1951
ORNL-1108	Period Ending July 31, 1951
ORNL-1161	Period Ending October 31, 1951
ORNL-1267	Period Ending January 31, 1952
ORNL-1302	Period Ending April 30, 1952
ORNL-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

1. Engineering Materials

G. M. Slaughter

This section has the responsibility for determining and evaluating the suitability of engineering materials for use in various energy systems, for developing new alloys, and for determining and developing improved joining and nondestructive testing techniques to assure the structural integrity of materials and components in specific applications. It comprises a staff of approximately 80, about 60% of whom are professionals. The research and development activities are carried out in five different laboratories, which carry the functional names Materials Compatibility, Mechanical Properties, Nondestructive Testing, Pressure Vessel Technology, and Welding and Brazing. Additionally, the Divisional support for the Heavy Section Steel Technology Program, the High-Temperature Gas-Cooled Reactor (HTGR) Structural Materials Program, and the Nuclear Regulatory Commission's Licensing Program report through this Section. A brief description of the work performed and accomplishments of each functional group and the NRC Licensing Program during the past year are presented below.

MATERIALS COMPATIBILITY

J. H. DeVan

The Materials Compatibility Group conducts corrosion and alloy development studies in support of fusion energy, gas-cooled reactor, fossil energy, space-nuclear, nuclear fuel reprocessing, and advanced technology projects.

We are supporting the Consolidated Fuel Reprocessing Program by qualifying and specifying materials for advanced fuel reprocessing plants. The experimental part of this program is being conducted at Battelle Columbus Laboratories under a subcontract that we monitor.

For several years we have studied corrosion in superheated steam at a Florida utility power plant. The program has provided data on a variety of steam generator materials under closely controlled steam conditions for long periods, and has examined the effect of high heat fluxes on the oxidation of a chromium-molybdenum steel. However, conversion of the plant from base load to peaking operation has forced termination of the program there. We are trying to locate another base load plant where we can continue the programs.

The group is actively studying thermal-gradient mass transfer processes in small natural-convection loops circulating liquid lithium and molten nitrate salt mixtures in support of the fusion and solar energy conversion programs. The lithium work is part of the fusion alloy development (ADIP) program and focuses on the corrosion of austenitic and ferritic steels and higher nickel alloys under the temperature and hydrodynamic conditions of conceptual fusion reactor systems. The attractiveness of mixed nitrate salts for energy transfer and storage has led to a study of the mass transfer behavior of types 304 and 316 stainless steel and alloy 800 in $NaNO_3$-KNO_3 under the sponsorship of Sandia Livermore Laboratories.

Corrosion programs related to fossil energy were conducted in support of atmospheric fluidized-bed coal combustion (AFBC) and direct coal liquefaction processes. The AFBC studies were concerned with the relationship between sulfur/oxygen ratios in the bed and sulfidation reactions of engineering materials with the bed environments. Our coal liquefaction corrosion studies included (1) examination of components from solvent refined coal (SRC) liquefaction plants, (2) the analysis of stressed and unstressed surveillance specimens following exposure in SRC pilot plants, (3) laboratory tests aimed at determining the corrosion mechanism in the fractionation area of SRC plants, and (4) tests of stress-corrosion specimens under controlled laboratory conditions. We also examined the corrosion resistance of engineering alloys in high-temperature oxygen-HCl environments used for the regeneration of catalyst in the Conoco $ZnCl_2$-catalyzed coal liquefaction process.

In support of the High-Temperature Gas-Cooled Reactor we are studying the carburization, oxidation, and vaporization of Hastelloy X and alloy 800H in helium containing ppm levels of H_2, CH_4, CO, and H_2O. Carburization, which accelerates creep as well as embrittles the alloys, appears to be rate controlled by the supply rate of the impurities to the alloy surface.

Development of iron-base long-range-ordered (LRO) alloys is jointly sponsored by DOE's Advanced Technology Projects and Magnetic Fusion Energy Programs. Our present efforts are concentrated on the development of LRO alloys based on $(Fe,Ni)_3V$ as structural material for advanced energy systems, with emphasis on fusion energy applications. The base alloys are modified with small amounts of alloy additions (e.g., Ti) for improvement of metallurgical stability and mechanical properties. We established that ferrovanadium can substitute for pure vanadium to provide a cheaper feed material for alloys.

Studies in support of space and terrestrial nuclear power systems are concerned with the development of high-temperature metal claddings for containment of PuO_2 fuel in radioisotope thermoelectric generators. Major emphasis has been on the characterization and qualification of DOP-26 alloy, Ir–0.3% W doped with 60 ppm Th and 50 ppm Al, for Galileo and solar-polar space missions. Also, refractory alloys (Mo and Mo-Re alloys) and ductile platinum-base alloys (Pt-Ru and Pt-Re) were studied as alternative cladding materials for future flight missions.

Both the LRO and iridium alloy development programs were recently transferred to the newly formed Alloying Behavior and Design Group.

MECHANICAL PROPERTIES

C. R. Brinkman

The Mechanical Properties Group develops data, qualifies new materials, and provides materials engineering support for ongoing national energy-related programs. During the last several years the effort has been primarily concerned with the behavior of structural materials at elevated temperatures. In this capacity the group has developed a strong capability for the characterization of materials in terms of their elastic, plastic, creep, and fatigue behavior. Percentages of our effort directed at various projects during this year within the group were approximately as follows: Fast Breeder Reactor, including Advanced Alloy Development (45%); High-Temperature Gas-Cooled Reactor (15%); Nuclear Regulatory Commission (5%); Fusion Energy (10%); and miscellaneous (25%). Highlights from specific programs were as follows:

Elevated-temperature mechanical property measurements in support of breeder reactor development included tensile, creep, fatigue, crack growth, and creep-fatigue interaction. These properties were obtained in support of specific component development tasks, such as the steam generator, constitutive equations, failure criteria, ASME Code support, and the *Nuclear Systems Materials Handbook*. This effort involved 125 creep, 7 fatigue, and 7 creep-plasticity and relaxation machines. Long-term creep tests were continued, with some tests in progress exceeding 70,000 h at temperatures (428–649°C) in many instances above the range of previous long-term data. Some long-term creep-fatigue tests of 2¼ Cr-1 Mo steel have exceeded nine months in duration. New experimental developments include the capability to conduct elevated-temperature multiaxial fatigue tests and the ability to subject large weldment specimens to creep deformation. Finally, a facility was completed for exposing large-diameter pipe to long-term prototypic stress and temperature conditions before mechanical property characterization.

Efforts continued to commercialize a modified 9 Cr-1 Mo alloy as a new elevated-temperature structural material. Two 15-ton heats were melted at Carpenter Technology Corporation. Both heats met the low-temperature (Charpy-impact) and the high-temperature (creep strength and ductility) property criteria set for this alloy. Testing continues to obtain properties for data packages for the acceptance of this alloy in Sections I and VIII of the ASME Code by the end of 1982. Eight tubes of this alloy were inserted in the superheater section in the Tennessee Valley Authority's coal-fired Kingston plant to obtain industrial and service experience. Two other utilities have agreed to insert tubing of this alloy into their boilers.

Operation of the Mechanical Properties Data Analysis Center (MPDAC) in support of the LMFBR development program continued. Activities within MPDAC include maintenance of an on-line computer data bank and analyses of data in support of the *Nuclear Systems Materials Handbook (NSMH)* and the ASME Code. Data analyses for the Metal Properties Council sought improved procedures for analysis of material strength data to establish ASME Code allowable stresses.

Mechanical property studies in support of HTGR development involved creep and fatigue studies conducted in impure helium. Since the design temperatures of gas-cooled systems were increased, the program was reoriented to include only nickel- and cobalt-base alloys in the wrought and welded conditions. The main problem is the loss of toughness and ductility due to carburization and phase changes within the alloys during prolonged exposure. Several test samples exposed up to 20,000 h in the impure helium will undergo creep and fatigue testing. The alloys being investigated exhibit different degrees of embrittlement, and we are attempting to develop alloys with improved properties.

The Nuclear Regulatory Commission-sponsored study of the creepdown of Zircaloy fuel cladding has ended with the completion of the eight successful in-reactor tests in the HFR reactor at ECN–Petten. These tests have produced creep rate data under both external and internal pressurization conditions at temperatures of 340 to 370°C.

Fatigue behavior is of particular interest to the design of the first wall of a magnetic confinement fusion reactor, since it operates in a cyclic or pulsed mode. Cold-worked (20%) type 316 stainless steel is the candidate material for the near term and requires extensive characterization in the irradiated condition. Fatigue life of samples irradiated to a fluence of 1.9×10^{26} n/m^2 was reduced by factors of 3 to 10. Alternate first-wall alloys such as niobium- and vanadium-base alloys were also fatigue tested at room temperature and 650°C and in high vacuum. Results show that Nb–1% Zr has only marginally better fatigue resistance than does 20%-cold-worked type 316 stainless steel in the low-cycle fatigue range. However, the former is more fatigue resistant in the high-cycle range.

NONDESTRUCTIVE TESTING

R. W. McClung

The Nondestructive Testing Group develops new or improved methods of nondestructive testing (NDT) and provides technical support in NDT. The activities range from long-range studies of physical mechanisms and theory to development of advanced techniques and equipment and to near-term applied development, technical support, and consultation. The program is broad-based, both from the technologies involved (including penetrating radiation, eddy current, ultrasonic, thermal, and penetrant techniques) and the projects (or agencies) represented, including several projects for both the DOE and the Nuclear Regulatory Commission (NRC).

The major activity for DOE has been on the Breeder Reactor Program (BRP). We began ultrasonic studies of austenitic stainless steel welds at temperatures up to 200°C with both machined discontinuities (e.g., notches and holes) and fatigue cracks. Ultrasonic frequency analysis and other signal processing techniques were investigated for improved flaw characterization in the steel welds. Eddy-current studies emphasized multiparameter multiple frequency techniques, and modular instrumentation containing an on-board microcomputer was applied in feasibility studies on stainless steel welds. For the Clinch River Breeder Reactor steam generator we developed prototype ultrasonic techniques and equipment for in-service inspection (ISI) of the tube-to-tubesheet (T/TS) joints, began development of microcomputer controls for the ultrasonic scanning, and continued development of eddy-current techniques for the ISI of the tubing. For alternate steam generator designs for BRP we provided technical support to manufacturers for radiographic and ultrasonic examination of welds.

Development and technical support were begun for both ultrasonic and eddy-current examination techniques for double-wall tubing for alternate steam generator designs. Preliminary techniques were applied to preassembly examination and in-service inspection.

Long-range NDT studies for the DOE Office of Basic Energy Sciences emphasized mechanisms for acoustic propagation across solid-solid interfaces with emphasis on isotropic-to-anisotropic boundaries, such as for the base metal-weld interface in austenitic stainless steel; advanced signal processing for flaw characterization; and very accurate eddy-current measurement of electrical conductivity. Other DOE programs include studies in x rays and ultrasonics for research reactor fuel, radiographic and ultrasonic developments for graphite, and technical support for the examination of alloys for space nuclear systems.

The largest activity for the NRC was directed toward improved ultrasonic standards for ISI of LWR pressure vessels and included consultation, interaction with ASME Code committees, and confirmatory laboratory experiments. Another activity consisted of providing primarily consultation in the evaluation of nondestructive examinations being performed on commercial nuclear reactors. For reactor safety research we continued to develop improved eddy-current techniques (with the aforementioned multiparameter technology) for the ISI of LWR steam generators.

PRESSURE VESSEL TECHNOLOGY

D. A. Canonico

The Pressure Vessel Technology Group is concerned with the fracture resistance of load-bearing materials.

The development of such information requires expertise in fracture toughness testing and interpretation of the data. Both DOE- and NRC-sponsored programs are conducted. Currently, the major emphasis is on the material property needs for the Heavy-Section Steel Technology (HSST), Fossil Energy (FE), HTGR, and Fusion Energy Programs.

Charpy V-notch (C_V) testing of irradiated weld metals that had low unirradiated C_V upper-shelf energy is continuing. Seven weld metals with 0.16 to 0.49% Cu lost less toughness than expected.

The fourth Bulk Shielding Reactor (4th BSR) experiment was started in December 1979. The capsule contains 60 1*T* compact specimens (1TCS), 90 Charpy V-notch specimens, and 10 tensile specimens, all of which were machined from HSST plate 02. This experiment has been irradiated for over 3000 h under excellent temperature control about 288°C (550°F). The 5th BSR experiment was started on June 25, 1980. Similar temperature control is anticipated with this capsule. It contains the same complement of specimens as the 4th BSR experiment except that the specimens were machined from 1980 state-of-the-art weld metal.

Material property data were obtained for Thermal Shock Experiment 5. We were asked to develop specified fracture toughness properties in material that satisfied the SA-508 class 2 chemical composition. The goal was accomplished by tempering a previously quenched 150-mm-thick (6-in.) cylinder at 615°C (1135°F) for 4 h. Tests showed a wide variation in fracture toughness when conducted in the Charpy V-notch transition temperature regime. These results provided the impetus for an extended fracture toughness testing program in which a number of specimens were tested at a single temperature. Current efforts to correlate ductile tearing at the fatigue crack terminus in 1TCS with fracture toughness values appear to be fruitful.

Studies relating the properties of prestressed concrete reactor vessel (PCRV) candidate liner steels to the K_{IR} curve in Appendix G of Sect. III of the *ASME Boiler and Pressure Vessel Code* is continuing. Preliminary data indicate that the equation will apply.

The activities in the fossil energy area have evolved around the properties of thick sections of 2¼ Cr-1 Mo steel for liquefaction or gasification pressure vessels. Cooling rates for section sizes up to 510 mm (20 in.) for steel quenched in highly agitated water from the austenitizing temperature were superimposed on a 2¼ Cr-1 Mo steel continuous transformation diagram. This information was used to obtain Charpy V-notch and tensile specimen blanks whose microstructure is identical with that of 305-mm (12-in.) section sizes. Those studies indicate that thick sections of 2¼ Cr-1 Mo steel will barely satisfy the tensile requirements of SA-387 grade 22 class 2 after a postweld heat treatment representative of commercial practice is imposed on the material. These results suggest that the higher strength specification for 2¼ Cr-1 Mo steel, ASTM A 542, will not be applicable for the fabrication of large thick-walled coal conversion pressure vessels.

WELDING AND BRAZING

G. M. Goodwin

The Welding and Brazing Group continues to conduct materials joining research and development in the areas of Light Water Reactors, Reactor Safety, Fossil Energy, Basic Energy Science, Gas-Cooled Reactors, Space-Nuclear, and Fast Breeder Reactors.

Light-Water Reactor and Reactor Safety Programs resulted in the completion of a study of the susceptibility of materials to lamellar tearing, a series of reviews of the reactor pressure boundary materials aspects of NRC Safety Evaluation Reports, and a significant contribution to the Advanced Instrumentation for Reflood Studies Program. In the latter, over 40 complex instrumentation assemblies have been fabricated and delivered to facilities in the Federal Republic of Germany and Japan.

The Fossil Energy Program has scaled up developmental weld overlay cladding techniques to commercial strip-cladding practice through industrial subcontract and initiated the procurement and evaluation of prototypic heavy-section vessel welds.

The Basic Energy Sciences welding study has expanded and has been recognized as a significant contribution to knowledge of solidification of austenitic stainless steels and iron-chromium-nickel alloys.

Gas-Cooled Reactor work continues to evaluate the weldability of candidate advanced high-temperature alloys in both wrought and cast form. Weld metal aged in GCR environments retained excellent mechanical properties.

For Space-Nuclear applications, our activities have led to improved weldability of iridium-base alloys and the development of high-power laser welding techniques.

Breeder Reactor Programs have demonstrated the commercialization of controlled residual element (CRE) stainless steel filler metals. Analyses have been conducted to better define the mechanisms involved in the observed mechanical property improvements. Evaluations of large-diameter pipe produced by advanced techniques have shown that elevated-temperature qualification testing should be performed, perhaps eliminating the arbitrary penalties applied to welds. The welding aspects of the newly developing 9% chromium alloys are being investigated. A computer-controlled system for electroslag casting has been installed and operated. Hopefully this system will permit the fabrication of improved austenitic-to-ferritic alloy transition joints.

NRC LICENSING ASSISTANCE – ENGINEERING

R. K. Nanstad

The Metals and Ceramics Division provides technical assistance to the Division of Engineering, Office of Nuclear Reactor Regulation, in support of its reactor licensing responsibilities. Current efforts are directed toward operating license review of Final Safety Analysis Reports for the Materials Engineering Branch and Mechanical Engineering Branch (program management only). The Materials Engineering Task includes the review and evaluation of three Boiling Water Reactors (two completed to date) scheduled for commercial operation within the next two years.

2. Fuels and Processes

R. G. Donnelly

Support for nuclear fuels research and development has continued to decrease again this year. These funding losses have been made up in large measure through new initiatives on alternate high-level nuclear waste forms. Although HTGR fuel development support has been reduced as has that for LWRs and BRs, the HTGR Program continues as the largest single program within the section. It is followed closely by the Space, Conservation, and Nuclear Waste Programs.

A summarization of activities within each functional group of the section follows.

CERAMIC TECHNOLOGY

R. L. Beatty

The Ceramic Technology Group has continued work on diverse programs, both continuations of previous work and new programs. The work scope included development, material testing, and technical support to DOE in nuclear fuel, fossil energy, conservation, solar, space power, and structural ceramics.

A new Industrial Conservation activity this year was aimed at utilizing glass furnace waste heat in a Brayton system for electricity generation. We obtained and modified a computer code for thermal analysis of glass furnace regenerators to determine if preheated air discharge from the Brayton system could be injected directly into regenerators without harm to their structural integrity.

In support of a DOE demonstration program for waste heat recuperators, we determined that stainless steel used in radiant recuperators corrodes by a sulfidation-oxidation mechanism. We recommended upgrading flue gas analyses and temperature measurements and installing surveillance specimens of alternate materials.

A new program characterizes candidate commercial ceramic materials for use in high-temperature solar chemical process heat receivers. Selected ceramic materials were exposed for several thousand hours to a sulfuric acid environment at 1000°C and then tested for corrosion effects. Two SiC samples and Y_2O_3-stabilized ZrO_2 showed excellent resistance to test conditions and will be tested at 1225°C. Success of these tests is important because the sulfuric acid cycle is the leading candidate for thermochemical water splitting.

A continuing study of HTGR pyrolytic SiC coatings by transmission electron microscopy (TEM) and other techniques was successful in characterizing microstructures and determining how important features depend on process variables. Out-of-reactor thermal gradient annealing of coated doped UO_2 microspheres gave strong evidence that release of silver and palladium is controlled by grain boundary diffusion. A technique for doping the UO_2 fuel kernels was developed.

Candidate structural ceramics were evaluated for HTGR core support materials. A literature review on creep and stress relaxation was published. Several high-performance silicon nitrides were characterized by TEM and other techniques in the as-received condition. Examination after creep testing will help identify creep mechanisms and predict behavior. A test system was built and used to expose selected ceramics to a simulated HTGR atmosphere. These tests are generating data on degradation of ceramic materials due to corrosive effects in the absence of stress, and will provide aged specimens for mechanical property measurements.

A new program to study the mineralogy and microchemistry of fly ash added significant insights to the detailed character and formation of this diverse material. We correlated characteristic components of fly ash with the source coal.

Electron microscopy of coals was expanded to include high-temperature (1000°C) transmission analyses. We observed important reactions of macerals with minerals and other macerals. Transmission near-infrared microscopy was developed and the knowledge obtained was transferred to industry for use in oil shale analyses. We developed a reliable new coke sulfur standard for microprobe users. We co-hosted a coal structure and properties meeting for the Basic Energy Science contractors of the Division of Materials Sciences of DOE.

Considerable progress was made this year in the understanding of graphite for structural design. Weibull statistics appear to apply rigorously to nuclear graphites as well as to aerospace grades. Indirect measurements on fracture mechanics also suggested that this approach to ultimate strengths is valid. Most interestingly, the surface energy does not appear to change with steam oxidation of graphite. If verified, a major simplification of the design of reactor graphite structural elements will be possible.

In cooperation with Y-12 we developed an advanced thermal insulation for space isotopic power sources. The carbon-bonded carbon-fiber insulation is planned for use in a General Purpose Heat Source. Over one hundred insulation parts were prepared for design and safety verification testing and determination of critical characteristics. The insulation contributes to a better safety margin as well as a weight savings that increases power density 7%.

We continued development and production of an Al_2O_3-Pt cermet for electrical insulation with very high thermal shock resistance for the Advanced Instruments for Reflood Studies (AIRS) Program.

We developed new materials to improve heat transfer in BN-insulated FBR simulated fuel rods. The problem caused by lower thermal expansion of BN than of the stainless steel sheath was ameliorated by placing a material of higher thermal expansion inside the heating coil. Non- or extremely slow-sintering MgO–15 wt % BN preforms were developed for this purpose. For tests in which nickel is used as the heating element a nonsintering MgO-graphite preform, which avoids the BN-Ni interaction, was developed.

FUEL CYCLE TECHNOLOGY

W. J. Lackey

This group develops processes and equipment for radioactive waste disposal and nuclear reactor fuels fabrication. Our major emphasis this year has shifted from fuels to high- and low-level radioactive waste disposal. The high-level waste effort utilizes sol-gel technology for preparation of spheres or pellets of crystalline ceramic waste forms. These waste forms incorporate the radioactive nuclides into solid-solution mineral phases having high leach and radiation resistance. New work in the area of low-level waste management focused on preparing functional criteria and a conceptual design for a proposed $25 million low-level waste pilot plant. Our fuels work is divided into three areas: (1) sphere-pac as an alternate to conventional pellet fuels, (2) fabrication of breeder reactor pellet fuels by pressing of gel-derived spheres (the sphere-cal process), and (3) fuel particle preparation and coating for HTGR fuels.

Fixation of high-level and transuranium radioactive waste in glass or alternative ceramic forms requires remotely operable processes and equipment, and sol-gel technology developed for reactor fuel refabrication appears applicable. Initial efforts at preparing gel-derived microspheres of the alternative crystalline ceramics Synroc-B and Synroc-B containing up to 25 wt % simulated Savannah River Plant waste slurry have been successful. Synroc spheres as large as 1 mm in diameter and of 95% theoretical density were prepared. Temperature and the atmosphere in which the spheres are dried have a strong effect on the integrity and density of the sintered spheres. Dilatometry revealed extensive sintering of Synroc at temperatures between 500 and 800°C. Ceramographic analyses revealed that (1) the grain size of sintered material was in the range of 1 μm and (2) the spheres were uniform in composition from center to surface. Microspheres of Synroc-B have been coated with pyrolytic carbon and silicon carbide by the chemical vapor deposition process. The transuranics Pu, Am, and Cm in Synroc-B partitioned into the perovskite and zirconolite phases.

A Low-Level Waste Pilot Facility (LLWPF) for developing and demonstrating technology for disposal of low-level radioactive waste has been proposed. It will receive beta-gamma contaminated combustible waste generated at ORNL, reduce its volume by incineration, and provide for final disposal by hydrofracture or other means. The facility will also have the capability for volume reduction of low-level contaminated metals and glass. The equipment will be sized to process 850 m^3 per year of combustible waste and approximately 15,000 kg per year of noncombustible waste. A feasibility study for this facility is currently under way.

Development of the sphere-pac process has continued on an engineering scale. Equipment was fabricated and installed to permit the loading and inspection of full-length (3–4 m) light water and breeder reactor fuel pins. These facilities met major goals of the program: loading fuel pins to acceptable overall density and verifying acceptable full-length density profiles. Another goal of the program was met by determination of the optimum nominal sphere size and particle size distribution of each of the three particle sizes in addition to the optimum amount of each particle size. Two unique blending concepts (feedback controlled vibratory feeders and continuous ring blender) were fabricated and tested on an engineering scale. Both systems were used successfully, but the continuous ring blender was favored (especially for remote use) because of its simplicity. The remote capability of the sphere-pac process was shown by the installation of an integrated fuel pin loading system. In this facility the fuel particles are pneumatically transferred from storage containers to the loading area, where they are volumetrically dispensed, blended, loaded into the fuel pin, and vibrated to achieve the desired density. The system requires no manual operation and is controlled by a remotely located minicomputer.

Preparation of fuel pellets from microspheres was strongly influenced by the density and crystallite structure of the spheres. High-density spheres having needle-type crystallites did not yield good pellets. On the other hand, good pellets were obtained from low-density material (<1.4 Mg/m^3), 300–600 μm in diameter having large platelet crystallites. Further, spheres having the desired characteristics could be prepared by growing the needles into platelets by hot oil aging or humidity-controlled drying of as-gelled spheres. Both approaches were used to successfully prepare UO_2 and $(U,Pu)O_2$ pellets. Thoria-urania spheres prepared by the external gelation process had desirably low crushing strength and gave suitable pellets. Processes have now been developed for preparing pellets from spheres for UO_2, $(Th,U)O_2$ and $(U,Pu)O_2$.

A potential HTGR fissile kernel is a highly dense microsphere of UO_2 and UC_2. A procedure was developed last year to convert and sinter spheres of UO_3 and carbon produced by internal gelation to the desired composition and density at temperatures as low as 1550°C. This year, the process was modified to use on microspheres made by external gelation. In many pyrolytic carbon coating runs, pyrocarbon produced by using CO_2 dilution had more open porosity than conventional coatings obtained with He, Ar, or H_2 dilutions. Despite the increased amount of open porosity, CO_2-diluted coatings were more gastight. The irradiation behavior of nine CO_2-diluted coatings will be examined in irradiation test HT-35, which is scheduled to begin in July 1980.

ENGINEERING COORDINATION AND EVALUATION

D. R. Johnson

We completed our activities in support of the Alternative Fuel Cycle Evaluation Program (AFCEP). We analyzed about 25 nuclear reactor fuel cycles identified by the Nonproliferation Alternative Systems Assessment Program. Direct responsibilities were the characterization of fuel fabrication plants using the gel-sphere pac process and the preparation of consistent cost estimates for all fuel fabrication and refabrication plants. We have published two additional ORNL reports and have contributed to a five-volume series of Hanford Engineering Development Laboratory reports that represent the final AFCEP report.

As part of the HTGR Development Program a relative evaluation of two reactor concepts was made. The Federal Republic of Germany has concentrated on the development of reactors fueled with small balls (pebble elements), while development in the United States has been primarily directed at reactors using hexagonal graphite blocks with axial fueled columns and alternating coolant holes (prismatic elements). We reviewed fuel fabrication processes for the two types of elements and prepared a consistent set of cost estimates for fabricating each element type in a commercial-scale plant. A report documenting the fuel fabrication process and cost estimates is in preparation.

We continued to provide technical management of the Residential Conservation Service (RCS) Program since assuming that responsibility in March of 1979. ORNL provides support in all three principal areas of program implementation (i.e., rulemaking, technical assistance to the states, and research and development). This support effort is being accomplished with staff members from six ORNL divisions, several subcontractors, and the Solar Energy Research Institute.

This year we developed a model procedure for residential energy audits, training materials for energy auditors, several guides for use by states in preparing their RCS plans, and an information management system. Several in-house research and development tasks were initiated this year. The topics under investigation are: (1) settling of loose-fill attic insulation, (2) thermal performance of attic insulation, (3) seasonal furnace efficiency, (4) certain aspects of indoor air quality, and (5) measurement of program effectiveness.

We have continued our work in the Fossil Energy Materials Program (FEMP) in the role of coordination and control of the FEMP management activities. Major activities that were completed in this program include work on a DOE-approved management plan, the preparation of a Technical Program Plan for the FEMP, the preparation of a Fossil Energy Materials Needs Assessment, the development of a management plan for program participants (subcontractors), and the preparation of an article for the *ORNL Review*.

ORNL is supporting Lawrence Livermore Laboratory in a broad program designed by the DOE Office of International Affairs to alert DOE Management to foreign energy-related technologies of potential value to the United States. As a subset of this international energy technology assessment (IETA) program, our group has the responsibility for obtaining information and assessing foreign activities in the selection and development of materials for use in coal liquefaction plants. The program began in April 1980 and has a six months activity, which will culminate in the preparation of a materials section for the topical report on coal liquefaction technology. Information gathering has begun with an extensive search of the published literature and available trip reports from U.S. foreign travelers.

During this period, we assumed a lead role in the materials design review and coordination of research and development for the Solvent Refined Coal (SRC) demonstration plant projects. We are assisting DOE-ORO in the review of contractor documents for materials selection, materials testing and failure analysis plans, and coordination of materials research and development for the SRC projects. We have met with contractors for the SRC demonstration plant projects. The mechanisms for performing the materials design reviews were established at these meetings, and we are proceeding with the task. We have reviewed several contractor documents and have provided comments to DOE. This will be a major activity throughout the Phase 1 (detailed) design periods for the SRC demonstration plants.

FUELS EVALUATION

F. J. Homan

Most of the support for the Fuels Evaluation Group continues to come from the HTGR Base-Technology Program, although partial support for two people in the group is being funded by Solar Programs.

The Irradiated-Microsphere Gamma Analyzer (IMGA) system continues to be the primary analytical tool for assessing the performance of HTGR fuel particles based on fission product inventory. A recent shift in emphasis to medium-enriched uranium (MEU)-thorium from the current reference highly enriched uranium (HEU)-thorium fuel cycle has resulted in an emphasis on the retention properties of SiC to silver and its interaction with palladium. The IMGA system can quantify the amount of silver retained as well as detect and isolate particles in which the SiC layer has failed.

The Postirradiation Gas Analyzer (PGA) system routinely measures the internal gas content of irradiated HTGR fuel particles. Over 500 individual particles have been broken in the PGA and their fission-gas contents measured quantitatively. Triso particles had uniform gas contents and were gastight. In contrast, Biso particles usually showed varied results, with a significant number permeable. The potential impact of this trend on the reference HTGR Biso fertile design is significant. Biso particles from an irradiation experiment specifically designed to test fast-neutron-induced permeability are being examined.

A remote x-ray micrographic facility has been installed in the High-Radiation-Level Examination Laboratory (HRLEL). This equipment can detect heavy metal and solid fission product migration within HTGR fuel particles, measure kernel swelling, and detect permeable Biso coatings when used in conjunction with hot gaseous chlorine leaching.

The HTGR "Umbrella" agreement between the United States and the Federal Republic of Germany includes a number of cooperative work areas between ORNL and Kernforschungsanlage (KFA) Jülich. Two areas in fuel development are active. One was formulated to investigate neutron-induced permeability in pyrocarbon (mentioned earlier). The other is to compare postirradiation techniques used at ORNL and KFA to assess the irradiation performance of coated particles. Topical reports describing the results will be coauthored by members of both laboratories.

Funding restraints in the HTGR Base-Technology Program and curtailment of the Recycle Program have significantly reduced the fuels development and irradiation testing at ORNL. The last two HTGR capsules that the Fuels Evaluation Group will be responsible for in coordinating the efforts of both General Atomic Company and ORNL are scheduled to be inserted in HFIR in late July 1980. General Atomic will assume the responsible role for future capsules in the HTGR Irradiation Program.

The Fuels Evaluation Group is involved in two tasks related to materials for utilization of high-temperature solar process heat. One task involves exposure testing of ceramic materials under candidate fuels-and-chemicals process environments. The other task is to assess current ceramic fabrication technology relevant to solar receivers for use in fuel and chemical processes.

The Fuels Evaluation Group also is involved in the development of a solar-tracking collector device for performance testing of various photovoltaic (PV) cells for a prolonged period of time to study atmospheric effects. This work is to improve the technical understanding of in-service PV cell behavior in concentrating systems in nonarid forested, agricultural, or industrial areas.

METALS PROCESSING LABORATORY

R. L. Heestand

Work continued in support of space and terrestrial power systems by supplying iridium containment for isotopic heat sources. Production of iridium disks for the Multihundred-watt Heat Source was completed and production for the General Purpose Heat Source began. The process developed previously for producing iridium sheet to finish thickness by hot and warm rolling rather than hot rolling and grinding was used. This process modification increases the yield of disks per rolled sheet by 25%, giving more efficient use of iridium, reducing production and characterization costs, and finally reducing losses of iridium by eliminating the need for recovery and refining of grinding residue. To eliminate surface contamination during finish rolling, tungsten carbide rolls and new furnaces were purchased and installed. We have assumed the additional responsibility for managing and refining all iridium used in space and terrestrial systems programs conducted at all DOE contractors. Also, ORNL has assumed the role of lead laboratory for overall materials problems for the entire heat source system.

A new effort in nuclear space power was initiated this year by fabricating experimental molybdenum heat pipes for Los Alamos National Laboratory in support of the Space Reactor Electric Power Supply. Efforts included manufacture of molybdenum screen tubes and assembly of the 3-m-long by 190-mm-OD heat pipes.

The waste management program on the "Volume Reduction of Low-Level TRU-Contaminated Metals by Melting" was continued; however, as the uranium contamination experiments were completed, the work has extended to investigate the removal of plutonium through slagging reactions. Experiments to date indicate that plutonium may be removed to the same degree as uranium. The full-size reduction facility plans have been postponed for lack of capital funding; however, full-scale documentation demonstrations are planned in 1981 utilizing the melting facility at Paducah.

In our program on the development of proliferation-resistant U_3O_8-Al research reactor fuel elements, all the sample plates for irradiation studies have been completed and have been assembled into elements. Sample plates fabricated by other DOE installations containing alternate fuels are also being assembled into test elements for irradiation studies. Management and surveillance of the fabrication of HFIR and ORR fuel elements are continuing; however, the decision of Texas Instruments, the contractor, to terminate fuel element fabrication has required that efforts to find and train an alternate fabricator be initiated.

Efforts have continued in fabrication of irradiation-resistant stainless steels for fusion energy devices. This includes fabrication of special heats at ORNL and coordination of the fabrication of production size heats by industrial companies. These materials are finished to size at the direction of the Radiation Effects Group and are distributed to all laboratories conducting fusion materials studies to permit correlation of test results.

3. Materials Science

J. O. Stiegler

The approach taken in programs conducted in the Materials Science Section is one of understanding the mechanisms governing the properties of materials in terms of processes occurring at the atomic level. Through such understanding we attempt to develop principles for the design of new or improved materials for advanced energy systems. Both basic and applied programs are pursued in the section, ranging from theoretical studies of the electronic structure of alloys through the actual development of fabrication procedures for producing controlled microstructures.

During the past year, two new groups have been organized to help focus our efforts. The Alloying Behavior and Design Group will utilize a basic understanding of alloying effects to examine stability and performance of new materials, with emphasis on high-temperature behavior. As its name suggests, the Structural Ceramics Group will concentrate on ceramic materials for high-temperature structural applications. In both groups the development of an understanding of structure-property relationships is the basis of the approach.

The development and understanding of structure-property relationships require the ability to define fully composition and microstructure at the atomic level. During recent years we have developed major microanalysis facilities, including high-resolution analytical electron microscopy, small-angle scattering, synchrotron radiation, Auger spectroscopy, and nuclear reaction and backscattering techniques. These are widely used in our existing programs, and during the past two years users groups have been established in all these areas. These are described in more detail in Chap. 6 of this report on Specialized Research Facilities and Equipment.

More complete descriptions of the activities and recent accomplishments of the groups in the section appear in the following paragraphs.

STRUCTURAL CERAMICS

V. J. Tennery

The work in this group has emphasized two major areas. One is the synthesis, fabrication, and characterization of hard ceramics, which may have potential as cutting tools or wear-resistant materials in critical applications, such as coal liquefaction plant pressure letdown valves. The other is the behavior of selected structural ceramics as heat exchanger (HX) materials in fossil fuel combustion environments. Work was also performed on growth of selected directionally solidified oxide-metal eutectics and single crystals, including fayalite, gehlenite, quartz, and actinide-doped monazite. Detailed analyses were also performed of the dislocation structures in explosively compacted alumina. A new project was also started to determine ways to increase the fracture toughness of structural ceramics by use of dispersed metastable second phases.

Following up our previous results from cutting tool tests for ceramics fabricated by hot-pressing the mixtures TiB_2-Ni, $(Ti,Cr)B_2$-Ni, and TiB_2-Fe, we are systematically studying the systems TiB_2-Ni and $(Ti,Cr)B_2$-Ni, including compositions up to about 30 mol % Ni, to determine the optimum conditions for fabricating high-density ceramics in these systems and to measure the resultant properties of these ceramics. For example, we determined that significant liquid-phase sintering occurs in ceramics initially composed of TiB_2 and nickel when they are hot-pressed at relatively low temperatures near the melting point of nickel. Relatively complex phase reactions during hot-pressing result in grain boundary phases that incorporate the nickel and are nearly as hard as the TiB_2 major phase. Experimental samples were tested at other laboratories for their erosion resistance to high velocity alumina particles as well as high velocity hot coal slurry impingement; preliminary results indicate these materials are roughly comparable to state-of-the-art cobalt-bonded tungsten carbides.

Several state-of-the-art structural ceramic materials for use in high-temperature HXs were tested for their stability during long-term exposures in high-temperature fossil fuel combustion environments in the Ceramic Recuperator Analysis Facility (CRAF), which became operational this year. The CRAF permits testing of structural ceramics in an HX configuration in actual fossil fuel combustion environments to temperatures of 1250°C for several hundred hours. Exposure of 14 different ceramic materials – including 4 types of silicon carbide, high alumina, and binary and ternary oxide-based ceramics – to the combustion products of a No. 6 oil at about 1200°C for approximately 500 h was completed and resulted in a marked increase in helium permeability in nearly all these materials.

In some cases, strength increased significantly. The permeability in some cases was several thousand times the preexposure values. The mechanism of the increase in helium permeability is being sought, as this increase could have a significant impact on consideration of ceramic HXs for use in advanced high-temperature closed-cycle gas turbine systems. Fuel impurities including nickel and iron reacted with the silicon phase in all siliconized silicon carbides analyzed. Iron and nickel were also observed to be relatively aggressive to ceramics originally consisting of 99.5% Al_2O_3.

Extensive studies were completed of directional solidification of $ZrO_2(Y_2O_3)$-$Al_2O_3(Cr_2O_3)$-Mo eutectics, and selected specimens are being evaluated as grain for metal grinding. We grew large enough fayalite crystals (Fe_2SiO_4) that several properties of this important mineral were measured by other laboratories, including the specific heat. Monazite crystals based on $LaPO_4$ containing ^{237}Np, ^{239}Pu, ^{243}Am, and ^{244}Cm were grown for the first time, in cooperation with the Solid State Division, for evaluating the phosphate as a host for immobilizing high-level actinide waste. The leachability of actinide species and selected physical properties are being determined for these crystals.

ALLOYING BEHAVIOR AND DESIGN

C. C. Koch

The Alloying Behavior and Design Group was organized in April 1980 to develop principles of alloying behavior and structure-property relationships and apply them to the creation of new materials and the modification of existing materials relevant to energy technology needs. The group has three major programs – (1) metastable materials, (2) deformation and mechanical properties, and (3) alloy design.

The initial efforts in the metastable materials program have involved development of facilities to produce amorphous alloys, studies of the formation and stability of amorphous phases, and the measurement of selected properties. This program supports the alloy design concept by providing advanced materials preparation facilities and basic alloying behavior studies.

The fundamental deformation and mechanical properties program will guide the structural alloy design projects. This program has focused on the role of interfaces and impurities in deformation and fracture at elevated temperatures. Initially, emphasis is placed on intergranular fracture in nickel and dilute nickel alloys studied by mechanical testing, microscopy, Auger electron spectroscopy, and theoretical modeling. Deformation and fracture experiments involving creep, recovery, and elevated-temperature fatigue have been started.

The present alloy design work is limited to part of the programs on iridium-base alloys for space power applications and the long-range-ordered (LRO) alloys in the $(Co,Fe,Ni)_3V$ system. The work on the LRO alloys has concentrated on a study of phase relations, structure, and mechanical properties. Plans are being formulated to significantly expand the alloy design effort into the areas of (1) ferritic steels for elevated-temperature applications, (2) a more general program on LRO alloys, and (3) molybdenum-base alloys.

PHYSICAL PROPERTIES

D. L. McElroy

Modern energy production and energy conservation technologies require knowledge and understanding of the energy transport phenomena acting in a variety of materials. Our efforts meet this need by developing and applying accurate physical property measurement techniques to metals and nonmetals from 4.2 to 2600 K. Analysis of these data is providing improved descriptions of the behavior of materials.

The Division of Materials Sciences supports our basic research. The electronic and phonon components of the thermal conductivity of pure α-iron, pure niobium, and pure tantalum have been identified by using physical property measurements on these elements and selected dilute alloys. The magnitudes of experimental values for the individual phonon scattering mechanisms compare favorably with theoretical expectations, except for tantalum, which seems to show an electron-phonon scattering value close to that of niobium. We are attempting to produce bulk samples of A15 compounds to examine cases of stronger electron-phonon scattering. Our electrical resistivity measurements from 4.2 to 300 K on palladium and dilute palladium-titanium alloys show that deviations from Matthiessen's rule do not reach a constant positive value at high temperatures. Results obtained by using low- and high-temperature apparatuses to span the range 20 to 1000 K were within the uncertainty claimed for standard reference material 735, a fully austenitic stainless steel. The low-temperature apparatus subsequently provided data on Nb–78 at.% Ti, which show that a rapid decrease in thermal conductivity occurs below T_c. A finite-difference heat conduction code was used to determine the temperature distribution in simple and selected experimental radial heat flow apparatuses. This revealed that nonideal heat flow can cause large apparatus errors, but these can be reduced by applying an experimentally determined "isothermal" correction. A radial technique provided thermal conductivity data on four beds of UO_2 microspheres and a bed of Al_2O_3 microspheres under a variety of conditions. Components have been assembled for an apparatus designed to measure several thermophysical properties of electrically conducting solids to 2600 K.

The Conservation Program supports research to improve the technical data base for building and industrial thermal insulating materials. We are active participants in ASTM C-16, particularly subcommittee C16.30 on thermal measurements. Our research focuses on determination of properties using in-house facilities and subcontracts. This provided determinations of thermal resistance values of a number of commercially available R-11 and R-19 batts, pipe insulations, and high-temperature fibrous insulations; development of low-thermal-conductivity screen wire heaters to measure the thermal resistance of insulations; a mathematical simulation model to bracket the thickness dependence of the thermal resistance of building and industrial insulations; temperatures of recessed light fixtures under normal conditions and when insulated and overpowered; density increases in loose-fill insulations due to vibrations; and measurements of a variety of properties of cellulose insulations including density, smolder combustion, moisture absorption, chemical permanency, and air flow resistance.

RADIATION EFFECTS AND MICROSTRUCTURAL ANALYSIS

E. E. Bloom

The primary objective of the Radiation Effects and Microstructural Analysis Group is to elucidate the role of microstructure, composition, and service environment on the behavior of materials and to develop materials with microstructure and composition tailored for specific applications. Two mission-oriented or applied alloy development programs (supported by the Office of Fusion Energy and by the Division of Reactor Research and Technology) are complemented by programs on radiation effects and analytical and high-voltage electron microscopy (supported by the Division of Materials Sciences). Electron microscopy (transmission, analytical, high voltage) and surface analysis techniques (Auger spectroscopy) are used to characterize structure and composition on a micro scale. The ORR, HFIR, EBR-II, ORIC, and 5-MV Van de Graaff are used in irradiation damage studies.

In the past year our research capability was significantly improved. Energy loss spectrometers were added to each of the analytical electron microscopes; a scanning Auger system with resolution of about 200 nm and computerized data acquisition became fully operational, and mechanical testing capability for irradiated samples was improved by the installation of an Instron with vacuum and environmental testing capability in the hot cells. From the research and development viewpoint, significant progress continued toward the development of radiation-resistant austenitic stainless steels for breeder and fusion reactor application. The fusion reactor alloy development program was expanded to include ferritic steels. Also, we began the first spectral-tailored irradiation experiment designed to achieve the ratio of transmutation-produced helium to displaced atoms expected in a fusion reactor. Development of a more comprehensive radiation damage theory continued, and significant progress was made in the irradiation creep investigations. The interaction of the analytical electron microscopy task with other programs in the Division and Laboratory was significantly expanded.

Analytical and High-Voltage Electron Microscopy

The research effort during the last year was nearly equally divided among diffraction research, electron energy loss instrumentation, and in situ experiments* in the high-voltage electron microscope. A smaller effort was expended on high-resolution experiments in an analytical microscope, and in addition a number of materials science investigations were begun.

A new electron energy loss spectrometer was designed, constructed, and interfaced with an analytical transmission-scanning electron microscope. Two spectrometers are now operational on analytical microscopes. At present a new multichannel analyzer and data collection system is being purchased for use with the newer spectrometer. When installation is completed, both analytical microscopes will have separate and independent data collection systems, which are interfaced to the common PDP-1134 computer for data analysis.

Convergent-beam diffraction research results obtained during the last year have shown that lattice defects such as straight dislocations and loops produce easily detectable changes in the patterns. Further, we were able to identify the Burgers vectors of both straight dislocations and loops by using convergent-beam diffraction patterns from very small areas of crystal containing the dislocations. A number of possible applications for this experimental method are currently being explored.

High-resolution experiments in the field emission gun analytical microscope have produced excellent results. In particular, this instrument has produced structure fringe images of silicon crystals viewed along [110] exhibiting "dumbbell" separation of atoms in the [001] direction with spacing 0.136 nm. This is equivalent to results produced within the last year or so by dedicated high-resolution microscopes elsewhere; the ability to produce such high-resolution images in an analytical microscope with its microchemical analysis capability and high-angle tilting stage adds immeasurably to its research capability. These high-resolution experimental results are the best ever achieved in an analytical microscope.

In-situ research of two types has been conducted in the high-voltage electron microscope, using the modified side-entry stage, whose installation was completed last year. Deformation and fracture of several ductile materials have been observed, among them austenitic stainless steel and Al—4% Cu alloy. Intense dislocation activity leading to microvoid formation near propagating ductile cracks has been observed. Some of these observations were recorded on video tape with a rather makeshift system. The results proved useful but of unsatisfactory image quality. An improved recording system will be put into operation during the next year. Experiments on in-situ oxidation of vanadium and of vanadium-titanium alloys have been continued. Oxygen absorbed in vanadium formed several new phases; the phase stability depends on foil thickness. This effect, which may be a result of elastic constraint or an oxygen concentration gradient, is being investigated.

Application of analytical electron microscopy to a number of important and interesting materials science problems began during the year. Grain-boundary regions in silicon-nitride-based high-temperature structural ceramic alloys have been examined and found to contain thin glass layers that differed in composition from the surrounding grains. Nickel-bonded titanium diboride cermets for use as wear resistant materials have been examined; new phases formed in grain-boundary regions during fabrication were observed. Ferritic steel creep specimens have been examined; some polygonization occurred during precreep heat treatment, and further polygonization occurred during creep. Carbide precipitated on defects in both types of specimen. These applications will be pursued further during the coming year, and other new ones will begin.

Fast Breeder Reactor Cladding and Duct Alloy Development Program

This work forms part of a national program to develop alloys with improved resistance to high-temperature irradiation damage for fast reactor core applications. Three major elements are involved: (1) the development of modified type 316 stainless steels with improved resistance to void swelling, (2) the assessment of the effects of irradiation on the high-strain-rate deformation and fracture behavior of advanced alloys, and (3) fabrication development.

Previous irradiation with 4-MeV nickel ions showed that the swelling behavior of type 316 stainless steel could be substantially reduced through modifications to the composition, principally through the addition of silicon and titanium. Based upon these initial studies, a series of austenitic stainless steel alloys with systematic compositional variations have been neutron irradiated in EBR-II, and their radiation response has been examined by analytical transmission electron microscopy. A complex series of phases develops during neutron irradiation at temperatures from 400 to 700°C. Through the combined use of electron diffraction and energy-

*"In situ" is used to describe experiments in which the specimen is observed under the electron microscope simultaneously with exposure to some nonambient condition, such as heating or straining.

dispersive x-ray analysis, the crystal structures and chemical compositions of eight major phases that develop during neutron irradiation have been determined. The swelling behavior of stainless steels is largely governed by the nature and distribution of these phases and by the partitioning of certain solutes between the matrix and the principal phases. Recognition of the importance of phase instabilities and their control through compositional modifications is an essential feature of the further development of low-swelling alloys.

The measurement of the postirradiation mechanical properties of advanced alloys has now been extended to alloys irradiated to fluences of 10^{27} n/m^2 (55 displacements per atom). The modified austenitic stainless steels and certain ferritic alloys showed good combinations of strength and ductility in tests designed to simulate reactor transient and seismic events and the stress conditions imposed during ex-reactor handling of fueled components. Nickel-base alloys, although stronger, frequently fail with limited ductility. Separation of the interface between eta phase platelets and the matrix was a major factor in promoting low-ductility transgranular failure in alloy 718 and intergranular failure in alloy 706. The interface is apparently weakened by both radiation-induced void formation and segregation of phosphorus.

The successful application of the titanium-modified stainless steels to the manufacture of cladding and duct components necessitates some modification to existing type 316 stainless steel fabrication technology. Beginning with an 80-mm-diam forging, hot working and cold working and annealing processes are being studied to improve our understanding of the physical metallurgy of producing a homogeneous product with good grain size control. This work is being conducted in close liaison with commercial vendors.

Alloy Development for Irradiation Performance

An extensive effort has been undertaken to develop alloys capable of withstanding the fusion reactor environment sufficiently long to achieve economical fusion power production. With this as a long-range goal, the program must also provide design data for alloys to be used in near-term experimental fusion reactors such as the Engineering Test Facility, ETF.

To reach both these goals, five alloy paths are being investigated. The first and most developed path consists of austenitic steels and is followed by ferritic steels, high-strength Fe-Ni-Cr alloys, reactive and refractory metal alloys, and innovative concepts, which at present consist only of long-range-ordered alloys. Austenitic and ferritic steels are being considered for both the ETF and the long-term applications; the remaining alloys are being considered only for the long term.

Helium produced by transmutation is a primary factor in determining irradiation-induced swelling, microstructural evolution, and mechanical property degradation. Since the helium effects tend to limit lifetime, they are the focus of much of the research. In nickel-containing alloys, helium may be introduced simultaneously with displacement damage through irradiation in mixed-spectrum reactors such as HFIR and ORR. A rather complex experiment is being conducted in ORR to produce the same helium-to-displaced-atom ratio in an austenitic stainless steel as will be produced in a fusion reactor.

The research has led to the development of a prime candidate austenitic stainless steel with improved radiation damage resistance. Research during the past year has focused on optimizing the thermomechanical condition for the alloy. The improved properties result from additions of titanium that result in precipitation of TiC particles. When the alloy is treated to produce a homogeneous fine distribution of TiC, the precipitate traps helium and prevents migration to grain boundaries and aggregation to form large bubbles. Phase stability during irradiation and the use of microstructural features such as dislocation substructures and precipitates to trap helium are under investigation. We identified a new phase that appears to be related to fracture in these alloys.

Fatigue tests of type 316 stainless steel irradiated in HFIR to damage levels from 5 to 15 displacements per atom and containing 200 to 1000 ppm He have shown reduction in life by a factor of 3–10 as well as an endurance limit at a strain range of 0.3%. This strain range corresponds to a thermal strain induced by a wall loading 5 MW/m^2 in a 3-mm stainless steel wall. This is within the acceptable design envelope.

Candidate ferritic alloys (HT-9, 9 Cr-1 Mo) have been modified with added nickel to produce helium upon irradiation now under way in HFIR.

Neutron irradiation experiments have been instituted to determine microstructural stability and mechanical properties of irradiated long-range ordered alloys.

A smaller emphasis is being placed on refractory metals, titanium alloys, and high-nickel alloys. Tensile, fatigue, and transmission microscopy specimens of these materials have been put in neutron irradiation experiments within the past year. Active research is being conducted to validate the cyclotron implantation method of helium doping in vanadium alloys.

The neutron irradiations and associated research will provide data for the ETF Title I design by 1984 for austenitic and ferritic alloys.

Radiation Effects

The mechanistic understanding of radiation effects in structural materials is developed in this Basic Energy Sciences task. The focus is on the types of phenomena and conditions characteristic of fission and planned fusion reactors. This task underlies the reactor alloy development programs, and mutual benefits are obtained by extensive interaction. An integrated theoretical and experimental approach is brought to bear on major problem areas. Present emphasis is on cavity swelling and irradiation creep.

Simultaneous nickel and helium ion bombardments have revealed great sensitivity of microstructure to the mode of helium injection. Ion bombardments of long-range-ordered alloys, ferritic materials, and zirconium have sought the mechanisms responsible for swelling resistance. Creep under ion bombardment has been investigated both at the ORNL irradiation creep facility at ORIC and in collaborative efforts using the compact cyclotron at KFA, Jülich, FRG. Irradiations of pure nickel in the high-voltage electron microscope have been analyzed with the rate theory of dislocation loop growth.

Ion-beam microanalysis using nuclear reactions has been continued on the Van de Graaf accelerator. Techniques for the depth profiling of deuterium, helium, carbon, and other impurities are now available. Analytical methods to extract diffusion coefficients and trapping parameters for these impurities are being developed.

The theory of radiation effects has been developed in a number of areas. (1) The theory of point defect trapping at impurities and the effects of impurity segregation, developed to explain the often observed lower swelling and irradiation creep rates in impure metals and alloys, has been extended. (2) The essential characteristic of radiation-produced microstructural features, such as cavities and dislocation loops, that is of primary concern in radiation effects is their sink efficiency for point defects. Significant progress has been made in the derivation and evaluation of such efficiencies. (3) Helium is a most important impurity and is produced by (n,α) reactions in reactor or injected deliberately during heavy ion bombardment. The effect of helium on cavity swelling, especially on the temperature dependence of swelling, has been analyzed. (4) Point defects are produced in cascades by spatially and temporally discrete energetic neutron collisions. Until recently the discrete nature and the resulting fluctuations in point defect concentrations have not been included in the theory of radiation effects. We have developed a cascade diffusion theory to include this physically more realistic mode of point defect production and have calculated the point defect fluctuations for both fission and fusion reactor conditions.

Structure and Properties of Surfaces

Surface analytical techniques are being used to study the influences of structure and composition of surfaces on plasma-wall interaction in fusion devices.

We are monitoring the changes in surface composition of samples of wall material exposed in the ISX-B tokamak and in the EBT toroidal confinement device to study impurity transport and to optimize impurity control. These studies are supplemented with studies in a small laboratory device where plasma-wall interactions can be studied over a wide range of controlled conditions. Here we are studying glow discharge cleaning to remove impurities from the wall. Helium and methane additions rapidly remove oxygen from the hydrogen working gas.

Similar techniques are being used to study the hydrogen-metal interactions. Recycling from the walls and limiters of tokamaks is the major source of hydrogen to the plasma. The composition and structure of the surface play a strong role in recycling from stainless steel walls, but the mechanisms involved are not well characterized or understood. We are studying these processes empirically and trying to determine which processes are most important and to what extent they can be controlled by materials selection and surface treatment. During the past year we have developed much better time resolution for these recycle studies and obtained data that indicate the relative importance of thermal and ion-induced processes under conditions of importance for today's tokamaks.

Unipolar arcing occurs in all tokamaks and may be the major source of metallic impurities in the plasma. Our previous studies correlated arcing with surface cleanliness and with plasma disruptions. We are continuing to study arcing in the ISX-B tokamak and have been able not only to measure currents and voltages to specially prepared samples but also to trigger arcs on these samples. This will permit studies of the transport of impurities from arcs through the plasma edge into the central plasma core so that the importance of arcing can be more readily assessed.

SURFACE AND SOLID-STATE REACTIONS

J. V. Cathcart

A major scientific objective of this group is to develop a better understanding of the mobility and structure of point defects in solids and to apply this knowledge in investigations of diffusion and oxidation (sulfidation) phenomena of relevance to the DOE mission. Defect mobility is the determining factor in the kinetics of various mass transport processes in solids (e.g., scale growth during corrosion, radiation damage, recovery processes). Point defects can influence the electrical, thermal, and mechanical properties of materials. Clearly, the phenomena we study are basic to a variety of technologically important processes.

The research consists of both theoretical and experimental programs. The conceptual development of *defect* diffusion theory provides the central theme of our theoretical work. Progress has been made in understanding correlation effects related to interstitial defect interactions and in the area of modeling diffusion in crystals containing large defect concentrations. This latter effort is particularly germane to diffusion in highly nonstoichiometric compounds such as $Fe_{1-x}S$. In a parallel series of experimental studies we are investigating the pressure dependence of the sulfidation kinetics and sulfide scale microstructure of iron.

Some previous research is being phased out so that we might concentrate more fully on sulfidation. Included is an investigation of the high-temperature oxidation of refractory metals and alloys typified by zirconium, niobium, and hafnium. This work has special relevance to reactor safety, and projects completed this year included the influence of oxide phase transformations, specimen geometry, and gaseous impurities on the steam oxidation kinetics of zirconium and zirconium-base alloys. The effect of alloying on oxidation kinetics and on oxygen diffusivities in the oxide scale and oxygen-stabilized α-zirconium layer was also determined. An investigation of tritium diffusion in alumina in the temperature range 800 to 1000°C emphasized the importance of dislocation arrays to the permeability of Al_2O_3.

THEORETICAL RESEARCH

J. S. Faulkner

We are developing new theoretical techniques in the area of multiple scattering theory, Korringa-Kohn-Rostoker (KKR) band theory, discrete variational method (DVM) band theory, cluster and layer methods for surfaces, coherent potential approximation (CPA) for random alloys, rigid muffin tin approximation for electron phonon interaction, and transport theory. We use these techniques to interpret and analyze the results of experiments in this laboratory as well as others, with the goal of broadening the scientific base for materials science.

The major theoretical advance of this reporting period in alloy theory is a new method for calculating the properties of random alloys from the solutions of the CPA equations. The method, which is based on newly derived formulas for the average Green's function, was proved necessary by unphysical behavior in calculations according to the formula previously available. The new method provides the necessary theoretical framework for calculating many observables that had previously been impossible to deal with. We are presently calculating the momentum density, which is used to interpret positron annihilation experiments.

We calculated the concentration dependence of the residual resistivity of Ag_cPd_{1-c} alloys entirely from first principles. The calculations reproduce the large asymmetry in the experimental data and are only off by about 30% for the magnitude.

Although both lithium and magnesium belong to the class of "simple" metals, the effects of alloying on the densities of states, as monitored by soft x-ray studies, are quite dramatic. We have calculated the densities of states for this system using the CPA, and find that the total density of states in the alloy is rather free electron like. Our calculated Li K and Mg L soft x-ray spectra compare well with experiments. This good agreement could never have been obtained with pseudopotential theory, which has hitherto been suggested as the best way to treat simple metals.

During the past two years, we have made substantial progress in understanding the electrical and thermal resistivities of transition metals. Extensions of the theoretical and computational techniques that we earlier applied to superconductivity in the transition metals have enabled us to solve the Boltzmann equation (which governs transport). We have obtained good agreement between theory and experiment without having to resort to adjustable parameters. This agreement gives us added confidence in the techniques that are central to the calculation of the superconducting transition temperature. We expect our work to have a significant impact on the way experimentalists analyze transport data.

Our major effort in surface theory during the past year has been the development of refined techniques for carrying out studies within a cluster framework, which focuses on the *local* bonding within a cluster of atoms. Our capabilities in this area are unique in that our DVM cluster techniques are directly related to those of our DVM energy band method, so that localization effects can be obtained by correlating results from our energy-band and cluster studies of a given system. We are continuing our studies of the precursor stages of aluminum oxidation (the molecular dissociation of O_2) in order to determine the basic mechanism of surface-induced dissociation. There is an increasing amount of experimental data on well-characterized single crystal samples, and our program will focus on relating the one-electron features for various bond sites to experiment in order to assess the capabilities of the surface probe for identifying surface species. We plan to extend our more elaborate cluster methods to treat the energetics in our oxygen-aluminum chemisorption studies.

X-RAY RESEARCH AND APPLICATION

H. L. Yakel

Our goals continue to focus on the design and implementation of scattering experiments at new, powerful radiation sources. Led by C. J. Sparks, Jr., G. E. Ice and B. S. Borie have developed optimal configurations for monochromators to be used at the ORNL station at the National Synchrotron Light Source, under construction at the Brookhaven National Laboratory. A. Habenschuss has assumed responsibilities for computer program development for this facility. R. W. Hendricks has been largely responsible for the successful completion and testing of the 30-m small-angle neutron scattering instrument at the High Flux Isotope Reactor. The NSF-funded laboratory has already received requests for experimental beam time from university and corporate research groups throughout the country. In cooperation with a group from the Los Alamos Scientific Laboratory, Hendricks has designed and tested a fast data-acquisition system that is essentially independent of the minicomputer controlling the experiment. The system should prove useful for the high counting rates anticipated at the NSLS and for time-slicing experiments at HFIR.

At the Stanford Synchrotron Radiation Laboratory, H. L. Yakel has obtained scattering data near both Fe *K* and Cr *K* absorption edge energies from a well-characterized binary iron-chromium sigma phase crystal that was quenched from 740°C. Results should precisely define atom distributions on the five non-equivalent lattice sites of this crystal.

During the Spring Quarter, B. S. Borie served as guest lecturer on x-ray diffraction physics in the Department of Materials Science and Engineering at the University of California at Berkeley. With R. W. Hendricks, he will cooperate in the intergroup research program to study fatigue in metals and alloys. Borie and Hendricks will assume responsibility for the important small-angle neutron scattering experiments that are a part of this effort.

In the area of small-angle x-ray scattering, R. W. Hendricks and S. Suehiro (a guest scientist from Kyoto University) have developed, tested, and applied a programmable function generator that will allow diffraction data to be collected from polymeric materials at preselected stages of cyclically varying applied stress or temperature. The experiments will yield unique data on the structural effects that accompany deformation and recrystallization in synthetic or naturally occurring polymeric substances. Extensions of the experiments to include amorphous metals and alloys are feasible.

We have again experienced a year in which our service facilities for x-ray diffraction have been heavily used. O. B. Cavin has examined nearly 450 samples submitted for analysis, and has cooperated with groups both internal and external to ORNL in specialized experiments. An automated powder diffractometer to expedite this work has been specified and bids have been received from potential vendors. Selection of a system is expected within the next reporting period.

4. Metallography

R. J. Gray, R. S. Crouse, and B. C. Leslie

The Metallography Group of the Metals and Ceramics Division provides technical assistance in areas of general metallography, postirradiation metallography, and electron-beam microanalysis (scanning electron microscopy and microprobe on both irradiated and unirradiated materials). This service is available not only to the Division but to the Laboratory as a whole as well as outside organizations, such as Battelle Northwest Laboratories, Savannah River Laboratories, TVA, and DOE. Highlighted below are the results of failure analysis and other metallographic findings not covered elsewhere in the report.

The apparatus used to transfer neutron activation samples into and out of the High Flux Isotope Reactor (HFIR) is fabricated of type 347 stainless steel tubing. This alloy is expected to undergo a 50% reduction in the ultimate elongation in a fast fluence of the intensity of the HFIR over a five-year period. The Operations Division decided to see if that lifetime might be extended in the interests of economy. Sections of a retired apparatus were submitted for postirradiation metallographic examination and microhardness, tensile, and bend testing. A definite increase in hardness was found but embrittlement was less than expected. Preliminary results seem to indicate that the five-year design life is very conservative.

In support of the fossil fuels programs, the Metallography Group has provided continuing surveillance of solvent refined coal plants in Wilsonville, Alabama, and Fort Lewis, Washington. This surveillance consists of sending people and equipment to the plant sites to perform metallography. In situ grinding, polishing, etching, replication, and microscopic examination is done to determine the cause of leaks in the fractionation column and piping. General attack and pitting as well as cracks were found.

During this period some special projects were carried out involving components from a boiling-water reactor nuclear power plant. We investigated (1) two 57-mm-diam, electrically operated pipe valve stems that had fractured, (2) the weldment in a 255-mm-diam pipe that had shown indications of a crack or flaw during routine ultrasonic testing, and (3) an unusual erosion-corrosion pattern in the interior surface of a 1.07-m-diam pipe. The failed valve stems had fractured at highly stressed thread roots. A fissure in the 255-mm-diam pipe was found in the base at a highly stressed location contiguous to the toe of the weld. The sensitivity of the routine ultrasonic surveillance was verified in this study since the fissure had penetrated only 15% of the pipe wall. The morphology of the erosion-corrosion patterns in the 1.07-m-diam pipe was studied in detail with scanning electron microscopy and optical microscopy. In each project, the investigations were conducted in close association with the representatives of the nuclear plant.

Deposition etching has been recently reemployed to reveal multiphase microstructures that are difficult to adequately etch chemically. A thin layer of material (TiO_2, ZrO_2, SiO_2, SnO_2, etc.) is vacuum deposited on a metallographic specimen, forming an interference film and giving rise to color contrast between phases. Examples of samples successfully contrasted by this method are siliconized silicon carbide heat exchanger material containing an iron-nickel eutectic, titanium alloy joined with an aluminum-silicon brazement, and titanium diboride, all extremely difficult to etch any other way. This technique appears to be very advantageous for revealing microstructures of dissimilar materials.

The last of a series of $^{90}SrF_2$ compatibility tests with TZM, Hastelloy C-276, and Haynes alloy No. 25 was examined for Battelle Northwest Laboratories. These samples were exposed for 30,000 h at 600 and 800°C. Photomicrographs were provided to Battelle for its analysis of compatibility.

The group service effort can be summarized by reporting that 2915 specimens were processed, 9366 black-and-white negatives made and printed, 975 slides produced, and 509 color negatives made and printed.

5. National Lead Offices and Technical Centers

The national lead offices already assigned and centered at ORNL by DOE and in which materials people play a key technical management role include National Program for Building Thermal Envelope Systems and Insulating Materials (BTESIM), National Fossil Energy Materials Program, and the Materials and Structures Technology Management Center (MSTMC). In addition, the Division is strongly promoting the establishment of a High-Temperature Materials Laboratory (HTML) to satisfy a pressing national need. A brief overview of activities performed at these centers during the past year is presented below.

THE NATIONAL PROGRAM FOR BUILDING THERMAL ENVELOPES SYSTEMS AND INSULATING MATERIALS (BTESIM)

Ted S. Lundy

The National Program involves the totality of research, development, and demonstration efforts on the thermal envelope for the nation's buildings, including output related to the design, construction, and operation of those structures. DOE has the lead federal role for promotion of energy conservation practices and has delegated much of its management responsibilities to ORNL. We were involved in the preparation of the initial National Program Plan for BTESIM (published January 1979) and are active in its continuing update and in its implementation through both in-house research efforts and subcontracts with other appropriate organizations. The Metals and Ceramics Division has the lead in measurement of properties of thermal insulating materials, while the ORNL Energy Division, NBS, and LBL have key roles in evaluations of components and systems that relate to the thermal performance of whole buildings. We expect to continue our lead role with emphasis on research, development, and demonstration projects essential in setting standards for greater energy efficiencies in buildings and on causing those improved standards to be used in retrofit and new construction practices.

FOSSIL ENERGY MATERIALS PROGRAM

R. A. Bradley

The Fossil Energy Materials Program at ORNL comprises three major activities:

1. management of DOE's Advanced Research and Technology Development (AR&TD) Fossil Energy Materials Program,
2. in-house research and development on the AR&TD Fossil Energy Materials Program, and
3. materials testing and design review in support of major construction projects, such as DOE's Solvent Refined Coal (SRC) demonstration plants and TVA's 200-MWe atmospheric fluidized-bed combustor.

The AR&TD Fossil Energy Materials Program, which addresses generic materials needs for all fossil energy technologies, is carried out at national laboratories, other government research laboratories, universities, and industrial research centers. During the past year, ORNL completed a fossil energy materials needs assessment and prepared a program plan to guide future work on this program. The management of most of the ongoing projects was transferred from DOE Headquarters to ORO and ORNL.

The in-house research and development on the AR&TD Fossil Energy Materials Program included measurement of fracture toughness and hydrogen attack of pressure vessel steels, weld overlay cladding with type 320Cb stainless steel, failure analysis and studies of general corrosion and stress-corrosion cracking in coal liquefaction plants, testing and evaluation of heat exchanger alloys for atmospheric fluidized-bed combustion, and evaluation of materials for ceramic heat exchangers. Significant progress was made in understanding corrosion in the fractionation area of coal liquefaction systems.

MATERIALS AND STRUCTURES TECHNOLOGY MANAGEMENT CENTER

J. R. DiStefano

As part of the U.S. DOE decentralization movement, ORNL and ORO have been assigned the responsibility to manage the national Materials and Structures Program (MSP) in support of the Liquid Metal Fast Breeder Reactor (LMFBR) Program. The Materials and Structures Technology Management Center (MSTMC) was established at ORNL to carry out this lead mission assignment because of the key role of personnel and programs under way in both the Engineering Technology and Metals and Ceramics Divisions.

The national MSP involves nine contractor organizations: Agbabian Associates, Argonne National Laboratory, General Electric Advanced Reactor Systems Division, Hanford Engineering Development Laboratory, Idaho National Engineering Laboratory, Naval Research Laboratory, Oak Ridge National Laboratory, Rockwell International Energy Systems Group, and Westinghouse Advanced Reactors Division. The two principal technology areas are (1) Structural Design, which includes High-Temperature Structural Design, Seismic Design, and Documentation, Liaison and Implementation and (2) Materials, which includes Mechanical Properties Design Data, Fabrication, Corrosion and Tribology, Advanced Alloy Technology, and Nondestructive Testing.

Overall program direction is provided by DOE Headquarters through long-range forecasting of trends and developing policy. Implementation of the national program is carried out by ORO through a program control system developed in conjunction with ORNL. The MSTMC provides detailed daily technical management, monthly cost performance analysis, and annual work scope and budget recommendations. It also issues semiannual and annual technical progress reports. One of the most significant accomplishments of the MSTMC in its first year of operation has been the development of national program plans for Mechanical Properties Design Data, Nondestructive Testing Technology, and Advanced Alloy Technology. Very important contributions were made by Metals and Ceramics Division personnel, who had lead roles in assisting the MSTMC in co-ordinating and developing these documents.

THE HIGH-TEMPERATURE MATERIALS LABORATORY

J. V. Cathcart

We have continued our efforts to establish a High-Temperature Materials Laboratory (HTML). This action is motivated by the recognition that high-temperature materials problems seriously limit the efficiency, reliability, and, in some instances, the feasibility of advanced energy-generating systems.

High-temperature phenomena tend to be complex and are most efficiently resolved by a multidisciplinary staff working cooperatively in a centralized facility. Consequently, we have proposed that the Office of Basic Energy Sciences of DOE fund the construction of an HTML at Oak Ridge. Because of budgetary constraints we plan a reduction in size of the HTML from about 7000 to about 4700 m^2 (80,000 to 50,000 ft^2). The total staff size (~75 professionals) will remain unchanged, although some research efforts will have to be housed in an adjacent building. As before, the staff expertise will encompass six functional research areas: Environmental Interactions, High-Temperature Chemistry, Physical Properties, Mechanical Behavior, Structural Characterization, and Materials Synthesis and Preparation. Assuming funding in FY 1982, the HTML should be ready for occupancy in late 1985.

In anticipation of the construction of the HTML, we have established a High-Temperature Materials Program, and the selection of a director for the HTML is in progress. The initial staff, which was recruited from existing groups in the Metals and Ceramics, Solid State, Chemistry, and Chemical Technology Divisions, consists of about 55 full-time employees, the large majority of whom are professionals. The initial program consists of both applied and basic research projects, reflecting our belief that interaction between basic and applied workers is essential in the HTML. Applied projects include an investigation of corrosion in a fluidized-bed combustor for coal and studies dealing with the evaluation and development of structural ceramics (principally silicon carbide and Al_2O_3) for use in heat exchangers. Basic studies are performed in all six of the functional research areas mentioned above, and some of these investigations (e.g., studies of sulfidation kinetics of iron and transport processes in FeS) are specifically designed to parallel the applied efforts.

We consider interaction with the university and industrial research community to be an essential feature of the effective operation of the HTML; when fully staffed, we anticipate an active users' program with 10 to 15 equivalent full-time participants per year. We have now initiated such a program, with personnel from the University of Virginia and Vanderbilt University spending time at ORNL to perform research utilizing the HTML's 1-MeV electron microscope and our analytical electron microscopy facilities.

6. Specialized Research Facilities and Equipment

During the past few years, several scientists have been heavily engaged in either converting existing or establishing new research facilities with unique capability to be operated in a user-dedicated mode. The underlying aim 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 academic community. The effort involves three specialized facilities: **SH**ared **R**esearch Equipment (SHaRE) Program, ORNL-ORAU Synchrotron Radiation Users Group, and the National Center for Small-Angle Scattering Research (NCSASR). A progress report covering the status of each activity is presented below.

SHARED RESEARCH EQUIPMENT PROGRAM

R. W. Carpenter

The Shared Research Equipment (SHaRE) program is a collaborative research venture between research staff members of ORNL and researchers in universities and industry. The program began a little over a year ago and has been enthusiastically received. The purpose of the program is twofold:

1. to permit ORNL research staff members to carry out additional research relevant to the DOE mission that would not otherwise be possible;
2. to make available to university faculty members, graduate students and postdoctoral research fellows sophisticated research equipment at ORNL that is not available in their home universities.

This program is directly supported by the Office of Basic Energy Sciences of the Department of Energy through ORAU. It is administered by ORAU under the direction of a steering committee whose members are:

William Felling, Assistant Director, ORAU
R. W. Carpenter, ORNL
C. L. White, ORNL
J. J. Wert, Professor, Vanderbilt University
E. A. Stark, Jr., Professor, Georgia Institute of Technology

At present there are ten active research programs with universities, one with private industry, and one with university and industry. The research involves high-voltage and analytical electron microscopy, Auger spectroscopy, and nuclear microanalysis. The results of this research continue to be reported in refereed scientific journals and at national and international scientific conferences.

USER-GROUP EXPERIMENTS AT THE NATIONAL CENTER FOR SMALL-ANGLE SCATTERING RESEARCH

R. W. Hendricks

The National Center for Small-Angle Scattering Research (NCSASR) at ORNL makes unique x-ray and neutron small-angle scattering facilities available to materials research scientists from university and industrial laboratories throughout the nation. Its 10-m x-ray and 30-m neutron scattering instruments, with their sophisticated computer-assisted data acquisition systems, open up possibilities for new kinds of diffraction experiments that could not be undertaken elsewhere. Interaction of ORNL staff scientists with the diverse external user community proposing work with these instruments provides opportunities for reciprocal growth of many ORNL-connected research programs.

To date, nearly one hundred proposals for small-angle scattering experiments in areas of polymer science, biophysics, and metals science have been received, over fifty of which are currently active. Most of these center on the proven capabilities of the 10-m x-ray system, but the potential uses of the newly completed neutron system have elicited a score of proposals for experiments at the frontiers of polymer and metal science.

X-ray scattering experiments sponsored by DOE during the reporting period have included studies of the decomposition of nickel-aluminum alloys by J. E. Epperson of Argonne National Laboratory and characterizations of the sizes and size-distributions of polymer-supported ferrofluids by G. D. Stucky and

D. W. Schaefer of Sandia Laboratories. Experiments sponsored by NSF with polymers under conditions of cyclic deformation or temperature variation have been conducted by groups from the Polymer Research Institute of the University of Massachusetts, the University of Tennessee's Department of Polymer Engineering, and the Textile Research Institute. Work on the structures of aggregated fibrinogen sponsored by NIH has been carried out by J. D. Ferry of the University of Wisconsin (Madison), while configurational changes in troponin and tropomyosin (proteins involved in skeletal and cardiac muscle contraction) have been measured by T. W. Barrett of the University of Tennessee Center for the Health Sciences, Memphis.

ORNL-ORAU SYNCHROTRON RADIATION USERS GROUP

C. J. Sparks, Jr.

The x-ray studies contained in the Materials Sciences Program as well as other programs at ORNL have made a major commitment to the use of intense synchrotron x-ray sources. This improved x-ray probe will be used to study the arrangements of atoms in solid-solution alloys, amorphous materials, and thin surface films and defect distributions in ceramic and metal systems. Many experiments not possible with our present x-ray sources will now become practicable.

We are heavily involved in the design and construction of the equipment needed to instrument one of the beam lines that will be available when the National Synchrotron Light Source is completed at Brookhaven National Laboratory in late 1981. Our university participants are involved with us in both planning and computer software development. An interim steering committee has been formed to guide the organization of some 20 universities and several ORNL staff into a collaborative research group using synchrotron radiation for advanced materials science studies.

ORAU is sponsoring the users group through proposals for funding to DOE to operate the beam line and to support personnel in the use of the facility.

Appendix A Budget and Support Distribution

The Division continues to operate in a secure financial condition. Adequate funds are available to support our staff and a healthy distribution in sources of funds is present.

Table A1 compares the money available to the Division for FY 1980 and for FY 1979. A large increase of $8,700,000 or 36% is shown for the Division. This figure is misleading however, since $7,000,000 of this increase is in funds allocated to subcontracting. The funds available for use within the Division increased by only $1,700,000, or 7%, which is not quite sufficient to cover the full cost of inflation.

This large increase in funds for subcontracting reflects our continuing increase in the number of program management activities. Funds for such activities usually require that a considerable percentage be spent on contracts outside the Laboratory. Such management activities (Chap. 5) are major portions of our fossil and conservation programs.

An optimistic observation from the data in Table A1 is that all programs except two are showing increases. A possible future problem is indicated by the appreciable decrease shown by fission, our largest single source of funds. These two observations indicate that the desired move from a completely fission-oriented division to a broader materials division is continuing. The percentage of funds for fission work has decreased from 36 to 28%. The increase of 49% in the fossil energy funds is thought to be an optimistic sign. Of the programs showing increases, two of the larger ones – Basic Energy Sciences and Fusion – show small increases, which are not quite sufficient to cover increases due to inflation. The NRC safety studies had been expected to decrease but instead show a healthy 62% increase. The decrease in advanced technology funding was disappointing since that had been looked upon as a possible source of long-range development funds. A lack of funds of this type still remains a major problem.

Table A1. Division Budget Fund Support Sources

	Actual FY 1979 ($K)	Current FY 1980 ($K)	Current FY 1980 (%)	Change ($K)
Advanced Technology	472	124	0.5	– 348
Basic Energy Sciences	4,986	5,269	21.7	+ 283
Conservation	1,087	1,310	5.4	+ 223
Fission	8,219	6,845	28.2	– 1374
Fossil	975	1,453	6.0	+ 478
Fusion	1,892	2,053	8.4	+ 161
NRC	1,380	2,233	9.2	+ 853
Solar	104	145	0.6	+ 41
Space	1,480	1,874	7.7	+ 394
Waste	190	708	2.9	+ 518
Other	562	994	4.1	+ 432
Service	1,287	1,300	5.3	
In-House Total	22,634	24,308		+ 1674
Outside Subcontracts	1,764	8,783		+ 7019
Total Division	24,398	33,091		+ 8693

Appendix B Personnel Summary

To staff a division as large and as diversified as Metals and Ceramics Division requires many types of employees. The variety of sources used to assemble our staff is shown in Table B1. These data also show that the Division has, during the past year, operated with a stable level of employment. Early in the year we expected that the staff would grow, and a recruiting campaign was begun. As discussed in Appendix A, the Division support remained fairly constant, and it was necessary to curtail the recruiting program.

During the year July 1, 1979, to June 30, 1980, a small decrease – three people – occurred in the permanent staff, with other categories remaining stable. The only significant change is an increase in the number of assigned guests, from 13 to 25.

The assigned guests are technical people who are funded by others but assigned to our Division to work. These people come from American and foreign universities, laboratories, and private companies. A few are assigned for short periods of time, 3 to 6 months, but most are here for a year or more. During the year we had a total of 37 guests assigned. Seven of these were from other laboratories or other Union Carbide divisions, while 30 were from outside the corporation. These guests were assigned largely to the Materials Science section. Supplementing our technical staff with 37 outside people is an effective and economical way of bringing in new ideas and viewpoints.

Although the total number of personnel was stable during the year, seven technical people left the Division and six new ones were obtained. These new people helped us maintain the high quality of our technical staff in that all had Ph.D. degrees and three were experienced senior people. During this period, ten support people left and eight new ones were obtained, resulting in a decrease of one technician. The decrease of one in the secretarial staff was compensated for by an increase of two part-time employees.

Table B1. Division Staff Composition as of July 1, 1979 and 1980

	Technical		Support		Total	
	1979	1980	1979	1980	1979	1980
Permanent employees	151	150	132	130	283	280
Temporary, >10 months	5	5	0	0	5	5
Division-supported loanees	1	6	6	1	7	7
Loaned out	3	2	1	1	4	3
Part time	8	8	3	5	11	13
Assigned guests	13	24	0	1	13	25
Coops (1/2 time)	0	0	4	6	4	6

Appendix C Organizational Structure and Chart

The Division is organized into a matrix structure to handle the dual administration of line organization by functional discipline and management of large, complex, and high-technology projects. Among the lead missions centered at ORNL and in which materials people play a dominant management role are National Building Energy Conservation Program, National Fossil Energy Materials Program, Energy Conservation and Utilization Technology Materials Program, and Materials and Structures Technology Program. The current organization of the Division is included here.

During the past year, a number of management openings occurred in both the line and project organizational structure and personnel were shifted to fill these positions. Upon his return from assignment in West Germany in the fall of 1979, P. L. Rittenhouse was appointed manager of the HTGR Structural Materials Program reporting to the Engineering Materials Section. In October of 1979, J. R. DiStefano moved to the Central Management Office and assumed the full-time position as manager of the materials technology post within the Materials and Structures Technology Management Center, reporting to W. O. Harms. In turn, P. Patriarca was named manager of the Breeder Reactor Materials Program within the Division, in addition to his assigned duty as manager of the ORNL Breeder Reactor Program. In December, V. J. Tennery moved to head of a new fundamental materials science group entitled Structural Ceramics, and R. L. Beatty replaced him as head of the Ceramics Technology Group in the Fuels and Processes Section. In January, R. J. Gray moved to a new assignment as senior staff engineer, and R. L. Crouse replaced him as leader of the Metallography Group in the Services Section. In April, the Alloying Behavior and Design Group was formed from the existing Physical Metallurgy and Metastable and Superconducting Materials Groups, and Carl Koch was named head of the new group. Finally, R. H. Cooper was appointed coordinator of the Space Power Programs, effective July 1, 1980, reporting to the Fuels and Materials Section.

METALS AND CERAMICS DIVISION

JULY 1, 1980

DIRECTOR
J. R. WEIR, JR.
F. R. COX

ASSOCIATE DIRECTOR
J. E. CUNNINGHAM
H. G. CORBETT
C. A. STRIZAK[1,2]

PROGRAMS

BASIC ENERGY SCIENCES PROGRAM
C. J. McHARGUE, MANAGER
L. M. PYATT*

BREEDER REACTOR MATERIALS PROGRAM
P. PATRIARCA, MANAGER
T. F. REEDY

CONSERVATION TECHNOLOGY PROGRAMS
A. C. SCHAFFHAUSER, MANAGER
K. B. DENNING

FOSSIL ENERGY MATERIALS PROGRAM
R. A. BRADLEY, MANAGER
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FUSION ENERGY MATERIALS PROGRAM
J. L. SCOTT, MANAGER
B. F. BYRUM

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F. J. HOMAN, MANAGER
M. B. WHITE*

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R. H. SHANNON

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H. G. SHARPE[1]
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E. S. BOMAR, JR.*

RESEARCH REACTOR PROCUREMENT
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HEAVY SECTION STEEL TECHNOLOGY PROGRAM
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HTGR STRUCTURAL MATERIALS PROGRAM
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R. H. BALDWIN
K. W. BOLING
E. BOLLING
B. L. P. BOOKER[1]
L. K. EGNER
J. C. FELTNER
J. L. GRIFFITH
B. McNABB, JR.
E. B. PATTON, JR.
L. T. RATCLIFF
C. O. STEVENS
B. C. WILLIAMS

NONDESTRUCTIVE TESTING
R. W. McCLUNG
L. ADLER[1]
K. V. COOK
W. E. DEEDS[1]
C. V. DODD
D. W. FITTING[1]
B. E. FOSTER
G. W. SCOTT
W. A. SIMPSON, JR.
J. H. SMITH
L. D. CHITWOOD
R. A. CUNNINGHAM, JR.
E. V. DAVIS
J. C. LEWIS

PRESSURE VESSEL TECHNOLOGY
D. A. CANONICO*
R. G. BERGGREN
W. R. CORWIN
D. O. HOBSON
C. J. LONG, JR.
R. K. NANSTAD*
W. J. STELZMAN
R. O. WILLIAMS
T. N. JONES, JR.
R. L. SWAIN

WELDING AND BRAZING
G. M. GOODWIN
S. A. DAVID
D. P. EDMONDS
J. F. KING
D. B. LLOYD[14]
J. W. McENERNEY
A. J. MOORHEAD
D. O. DOYLE[14]
S. E. HANZELKA
J. W. HENDRICKS
V. T. HOUCHIN[7]
J. D. HUDSON
T. D. OWINGS, JR.
R. W. REED, JR.
J. W. SHAW
J. J. WOODHOUSE

SPECIAL PROJECTS
T. L. HEBBLE[12]
J. T. HUTTON[13]

MATERIALS SCIENCE

J. O. STIEGLER, SECTION HEAD
L. M. PYATT*
S. P. BUHL
F. M. FOUST
C. L. HARRISON
A. G. GOLLIHER
F. A. SCARBORO
J. F. YOUNG

HIGH TEMPERATURE MATERIALS LABORATORY
J. V. CATHCART*

USERS GROUPS

ORNL/ORAU SHARED RESEARCH EQUIPMENT PROGRAM
R. W. CARPENTER*

SMALL ANGLE X-RAY SCATTERING LABORATORY
R. W. HENDRICKS*

ORNL SYNCHROTRON X-RAY SOURCE USERS GROUP
C. J. SPARKS*

ALLOYING BEHAVIOR AND DESIGN
C. C. KOCH
A. DAS GUPTA
D. S. EASTON
D. M. KROEGER
C. T. LIU
J. C. OGLE
R. A. VANDERMEER
C. L. WHITE
M. H. YOO
J. O. SCARBROUGH
R. A. PADGETT
C. E. ZACHARY

PHYSICAL PROPERTIES
D. L. McELROY
W. W. HARRIS
S. H. JURY[1]
J. P. MOORE
R. K. WILLIAMS
D. W. YARBROUGH
R. S. GRAVES
F. J. WEAVER

RADIATION EFFECTS AND MICROSTRUCTURAL ANALYSIS
E. E. BLOOM
J. BENTLEY
D. N. BRASKI
R. W. CARPENTER*
W. B. CARTER[8]
R. E. CLAUSING
W. A. COGHLAN
C. K. H. DuBOSE
L. C. EMERSON
K. FARRELL
A. P. FISHER
M. L. GROSSBECK
J. A. HORAK
L. L. HORTON[21]
E. A. KENIK
R. L. KLUEH
E. H. LEE
G. L. LEHMAN[15]
M. B. LEWIS
L. K. MANSUR
P. J. MAZIASZ
N. H. PACKAN
T. C. REILEY
A. F. ROWCLIFFE
P. S. SKLAD
J. E. SPRUIELL[1]
M. TANAKA[18]
J. M. VITEK
F. W. WIFFEN
R. A. BUHL
S. W. COOK
B. L. COX
L. T. GIBSON
L. HEATHERLY
J. T. HOUSTON
C. G. McKAMEY
G. A. POTTER
W. H. SMITH
L. J. TURNER

STRUCTURAL CERAMICS
V. J. TENNERY
P. F. BECHER
G. W. CLARK
C. B. FINCH
O. C. KOPP[1]
C. S. YUST
L. L. HALL
S. B. WATERS

SURFACE AND SOLID STATE REACTIONS
J. V. CATHCART*
R. E. DRUSCHEL
R. A. McKEE
R. E. PAWEL
G. F. PETERSEN
J. J. CAMPBELL
L C MANLEY, JR.

THEORY
J. S. FAULKNER
F. W. AVERILL[20]
T. P. BEAULAC[23]
W. H. BUTLER
A. T. FROMHOLD[23]
G. S. PAINTER
F. J. PINSKI[23]
G. M. STOCKS

X-RAY RESEARCH AND APPLICATION
H. L. YAKEL
B. S. BORIE
O. B. CAVIN
A. HAUBENSCHUSS[15]
R. W. HENDRICKS*
G. E. ICE
P. LaBARBE[25]
C. J. SPARKS, JR.*
S. SUEHIRO[24]

FUELS AND PROCESSES

R. G. DONNELLY, SECTION HEAD
M. C. MATTHEWS
M. S. BOOKER
R. L. CASTLEBERRY
S. L. McCANELLY
M. B. WHITE*
P. A. WHITE

ALUMINUM FUEL ELEMENT DEVELOPMENT PROGRAM
M. M. MARTIN*

GRAPHITE PROGRAMS
W. P. EATHERLY

NATIONAL BUILDING ENERGY CONSERVATION PROGRAM
T. S. LUNDY

SPACE POWER PROGRAMS
R. H. COOPER, JR.

CERAMIC TECHNOLOGY
R. L. BEATTY
E. S. BOMAR, JR.*
J. I. FEDERER
L. A. HARRIS
C. R. KENNEDY
R. J. LAUF
C. S. MORGAN
A. E. PASTO
G. C. WEI
B. R. CHILCOAT
D. B. FIELDEN
J. W. GEER
C. HAMBY
F. P. JEFFERS
P. J. JONES
H. KEATING
S. S. RAWLSTON
J. F. WILLMERING

ENGINEERING COORDINATION AND EVALUATION
D. R. JOHNSON
P. T. CARLSON
R. R. JUDKINS
A. R. OLSEN
T. F. SCANLAN
H. R. LIVESAY

FUEL CYCLE TECHNOLOGY
W. J. LACKEY
P. ANGELINI
A. J. CAPUTO
J. E. MACK
J. M. McNAIR[19]
D. P. STINTON
H. J. WALLACE
L. C. WILLIAMS
C. E. DeVORE
W. H. ELLIOTT, JR.
J. B. FLYNN*
G. F. GALLOWAY
M. S. HENDRICKS
J. C. McLAUGHLIN
W. B. STINES
R. L. WHITE

FUELS EVALUATION
F. J. HOMAN*
M. J. KANIA[9]
E. L. LONG, JR.
J M ROBBINS
T. N. TIEGS
E. L. RYAN

METALS PROCESSING
R. L. HEESTAND
G. L. COPELAND
D. E. HARASYN
B. HESHMATPOUR
R. W. KNIGHT*
M. M. MARTIN*
R. E. McDONALD
T. K. ROCHE
G. E. ANGEL
K. S. BLAKELY
W. H. DAVIS
C. E. DUNN
C. W. HOLLAND
R. L. MARTIN
L. QUEENER
C. L. QUIMBY

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*DUAL CAPACITY
[1]PART TIME
[2]ON LOAN FROM CENTRAL MANAGEMENT OFFICE
[3]TEMPORARY ASSIGNMENT
[4]ON ASSIGNMENT TO LONG RANGE PLANNING
[5]ON ASSIGNMENT FROM KFA, JÜLICH
[6]ON LOAN FROM FINANCE AND MATERIALS DIVISION
[7]ON ASSIGNMENT FROM PLANT AND EQUIPMENT DIVISION
[8]LABORATORY GRADUATE PARTICIPANT PROGRAM FROM GEORGIA TECH
[9]ON ASSIGNMENT TO KFA, JÜLICH
[10]ON LOAN FROM INFORMATION DIVISION
[11]ON ASSIGNMENT TO AERE HARWELL
[12]ON ASSIGNMENT FROM COMPUTER SCIENCES DIVISION
[13]ON ASSIGNMENT FROM INSTRUMENTATION AND CONTROLS DIVISION
[14]ON ASSIGNMENT FROM ENGINEERING TECHNOLOGY
[15]GUEST, OAK RIDGE ASSOCIATED UNIVERSITIES
[16]ON ASSIGNMENT TO ILLINOIS INSTITUTE OF TECHNOLOGY
[17]ON LOAN TO CMO BREEDER REACTOR PROGRAM
[18]GUEST, JAPAN ATOMIC ENERGY RESEARCH INSTITUTE
[19]ON ASSIGNMENT FROM GENERAL ATOMIC
[20]FACULTY RESEARCH PARTICIPANT FROM JUDSON COLLEGE
[21]GUEST, UNIVERSITY OF VIRGINIA
[22]GUEST, AUBURN UNIVERSITY
[23]GUEST, STATE UNIVERSITY OF NEW YORK
[24]GUEST, KYOTO UNIVERSITY, JAPAN
[25]GUEST, UNIVERSITE de MONTPELLIER, FRANCE

Appendix D Honors and Awards

Division staff members continue to be cited and rewarded for exhibiting outstanding talent and ability in fulfilling their professional roles within the scientific and engineering community. The type of recognition received or professional achievement attained tends to fall into one of the following six specific categories: honors, awards, commendations, elected officers and members, certification and registration, and appointments. A chronological listing of citations in each of these categories during the past year follows.

HONORS

July 1979

Larry A. Harris' work on the characterization of coal, identifying three organic constituents in aggregate bituminous coal, was featured in color on the cover of the July issue of *Metal Progress.*

November 1979

Anthony C. Schaffhauser, John V. Cathcart, and *James O. Stiegler* were elected Fellows of the American Society for Metals.

James R. Weir, Jr. was elected "Eminent Engineer" by the Tennessee Alpha Chapter of Tau Beta Pi for outstanding attainment in the field of engineering.

January 1980

Carl C. Koch and *Harry Yakel, Jr.* were elected Fellows of the American Association for the Advancement of Science.

April 1980

Ronnie A. Bradley was elected a Fellow of the American Ceramic Society.

May 1980

Robert W. McClung was selected and named an Outstanding Engineering Alumnus by the University of Tennessee.

June 1980

Robert W. McClung was named a Fellow of the American Society for Testing and Materials in recognition of his outstanding contributions to the advancement of voluntary standardization.

AWARDS

July 1979

C. W. (Pete) Houck, Faye F. Russell, and *Roy T. King* received the first place award in Optical Microscopy Category, Class 1 on Iron, Steel, Stainless Steel, Nickel, and Nickel Alloys, for their entry on "Metallographic Examination of Type 310 Stainless Steel Air Distributor Plate from an Atmospheric Fluidized Bed Combustor (AFBC)" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

Vinod K. Sikka, Stan A. David, C. W. (Pete) Houck, and *Elmer H. Lee* received second place in Optical Microscopy Category, Class 1 on Iron, Steel, Stainless Steel, Nickel, and Nickel Alloys, for their exhibit on "Ingot Grain Structure Causes Significant Variation in Creep-Rupture Properties of Cast Type 316 Stainless Steel" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

John D. Holder, William H. Farmer, and *G. Wayne Clark* received first place in Optical Microscopy Category, Class 3 on Petrographic, Ceramographic, and Cermet Materials, for their entry on "Analytical Metallography Reveals Clustering in Cr_2O_3-Mo-Re melts" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

David N. Braski (with H. Schroeder and H. Ullmaier, KFA, Jülich, FRG), received first place in Electron Microscopy Category, Class 4 on Transmission, for the exhibit on "Helium Embrittlement of Austenitic Stainless Steel" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

David N. Braski, Raymond W. Carpenter, and *Chain T. Liu* received second place in Electron Microscopy Category, Class 4 on Transmission, for their entry on "The Microstructure of Ordered Alloys $(Co,Fe)_3V$" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

July 1979

Stan A. David, David N. Braski, C. Paul Haltom, and *Rosemary C. Robertson* received first place in Electron Microscopy Category, Class 5, Analytical, for their exhibit on "STEM Microanalysis of Austenitic Stainless Steel Weld Metal" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

John D. Holder, William H. Farmer, Jay W. Nave, and *G. Wayne Clark* received first place in Color Micrographs, Class 9, for their entry on "Interference Colors Aid in Study of Cr_2O_3-Re Eutectic Composites" at the International Metallographic Exhibit of the International Metallographic Society in Tamiment, Pennsylvania.

September 1979

Chain T. Liu, Henry Inouye, and *Anthony C. Schaffhauser* received an I•R-100 Award from *Industrial Research* for development of Ductile Ordered Transition-element Alloys (DOT), as one of the 100 most significant new products or developments of 1979 of interest to scientists and engineers.

W. Jack Lackey, Robert R. Suchomel, Ronald L. Beatty, David P. Stinton, Peter Angelini, Anthony J. Caputo, Arvid E. Pasto, Ernest L. Long, Jr., James A. Horak, Ralph G. Donnelly, and *J. E. Mack* (with staff members from the Chemical Technology Division) received an I•R-100 Award from *Industrial Research* for development of the Gel-Sphere-Pac Nuclear Fuel Fabrication Process, as one of the 100 most significant new developments of 1979 of interest to scientists and engineers.

November 1979

J. Peyton Moore received the International Thermal Conductivity Award at the 16th International Thermal Conductivity Conference in Chicago for his contributions in thermal conductivity research on materials of interest to basic research and on materials of applied importance.

January 1980

Sloan Bomar and *Victor J. Tennery* (with H. R. Meyer, J. E. Till, W. D. Bond, L. E. Morse, and M. G. Yalcintas) received a second place 1980 Technical Communication Award from the East Tennessee Chapter of the Society for Technical Communication for their paper, "Radiological Impact of Thorium Mining and Milling."

Caius V. Dodd and *Dave O. Hobson* (with K. R. Thoms and Th. van der Kaa) were awarded a plaque by the Materials Science and Technology Division (MSTD) of the American Nuclear Society for their presentation, "An Irradiation Capsule Design Capable of Continuously Monitoring the Creepdown of Zircaloy Fuel Cladding."

April 1980

Domenic A. Canonico received the 1979 James E. Lincoln Gold Medal Award from the American Welding Society for the best paper with one author published in the *Welding Journal* during the 12-month period ending with the December issue for his paper, "Significance of Reheat Cracks to the Integrity of Pressure Vessels for Light-Water Reactors."

David N. Braski, Stan A. David, and *Gene M. Goodwin* received the 1979 McKay-Helm Award from the American Welding Society for their paper, "Solidification Behavior of Austenitic Stainless Steel Filler Metals."

April 1980

Peter Angelini, David P. Stinton, W. Jack Lackey, Charles E. DeVore, Tommy J. Henson, Larry G. Shrader, and *Noble H. Rouse* received first place in its category, unique techniques, and Best of Show for their poster in the Ceramographic Contest at the American Ceramic Society Annual Meeting in Chicago, Illinois.

George C. Wei, Robert S. Crouse, and *Victor J. Tennery* received best in class, Refracture Optical Microscopy, at the Ceramographic Contest at the American Ceramic Society Annual Meeting in Chicago.

John I. Federer, Victor J. Tennery, and *Tommy J. Henson* were awarded first place in its class, Natural Surfaces, for their poster, "Fuel Impurities Exhibit

Partitioning in Fiber Insulation Linings at High Temperatures," at the Ceramographic Contest at the American Ceramic Society Annual Meeting in Chicago.

June 1980

Chain T. Liu received the first annual Henry J. Albert Award from the International Precious Metals Institute for his contributions in the field of metallurgy of precious metals.

Robert W. McClung received an Award of Merit from the American Society for Testing and Materials.

COMMENDATIONS

December 1979

Sloan Bomar received an ORNL Letter of Appreciation for his service on the Radioactive Operations Committee (ROC) over the years.

January 1980

Marjorie C. Matthews received a Letter of Appreciation from Dow Chemical U.S.A. for her participation on the Conference Planning Committee for the ASHRAE-DOE Conference, Thermal Performance of the Exterior Envelope of Buildings.

March 1980

James R. Weir, Jr., received an ORNL Certificate for his winning Quality Assurance message: "The worker to be prized is quality wise."

April 1980

Caius V. Dodd received a Letter of Appreciation and Recognition from Sprague Electric Company for his helpful discussions and state-of-the-art literature on eddy-current testing.

Charles R. Brinkman received a Letter of Appreciation from DOE for his participation in the training seminars for new members of the Clinch River Breeder Reactor Project (CRBRP) Office.

ELECTED OFFICERS AND MEMBERS

July 1979

Robert S. Crouse was elected Membership Chairman of the International Metallographic Society.

August 1979

Everett E. Bloom was elected Chairman of the Oak Ridge Chapter of American Society for Metals for the 1979–80 term.

September 1979

Robert W. Hendricks was elected to membership on the Chemistry and Physics of Metals Committee of the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers.

December 1979

Walter P. Eatherly was reelected Vice Chairman of Committee C-5, Manufactured Carbon and Graphite, of the American Society for Testing and Materials for a two-year term.

January 1980

Raymond W. Carpenter was elected to a term as Director, Physical Sciences, of the Electron Microscopy Society of America.

Richard J. Beaver was elected 1st Vice Chairman of Committee E-46 of the American Society for Testing and Materials for a two-year term.

June 1980

Martin L. Grossbeck was elected a member of the Executive Committee of the Materials Science and Technology Division of the American Nuclear Society.

CERTIFICATION AND REGISTRATION

August 1979

Joseph W. McEnerney was certified a Registered Professional Engineer in the State of Tennessee.

APPOINTMENTS

August 1979

David L. McElroy was appointed to the Editorial Board of the *International Journal of Thermophysics,* a quarterly publication, starting in 1980.

September 1979

Richard J. Beaver was appointed Chairman of the Editorial Subcommittee and a member of the Executive Subcommittee Al on Steel, Stainless Steel, and Related Alloys of the American Society for Testing and Materials.

Robert W. McClung was appointed to the Awards Committee of the American Society for Nondestructive Testing for a one-year term.

Gene M. Goodwin was appointed to the Committee on Anchor Chain Manufacture of the National Academy of Sciences.

November 1979

Robert W. McClung was appointed a member of the Subgroup on Ultrasonics and Acoustic Emission (SC V), Boiler and Pressure Vessel Committee, of the American Society of Mechanical Engineers for a five-year term.

January 1980

W. Jack Lackey was appointed to serve on the 1980 Postdoctoral Research Associateship Program, Engineering and Applied Sciences Panel, of the National Research Council Commission on Human Resources.

March 1980

John E. Cunningham was reappointed a member of the Advisory Technical Awareness Council of the American Society for Metals for a three-year term.

Carl J. McHargue was appointed a member of the International Metals Reviews Committee of the American Society for Metals for a three-year term.

April 1980

W. Jack Lackey was appointed to the Materials Review Board of the Office of Nuclear Waste Management of DOE as the ORNL representative.

May 1980

Domenic A. Canonico was appointed to the Boiler and Pressure Vessel Main Committee of the American Society of Mechanical Engineers for a five-year term.

W. Jack Lackey was appointed to the 1980-1981 Program Committee of the American Ceramic Society Nuclear Division.

Gerald M. Slaughter was appointed 2nd Vice Chairman of American Society for Testing and Materials-The American Society of Mechanical Engineers-Metal Properties Council (ASTM-ASME-MPC) Joint Committee on the Effect of Temperature on the Properties of Metals.

June 1980

James L. Scott was appointed to the Publications Steering Committee of the American Nuclear Society for three-year term.

Nick H. Packan was appointed Chairman of Subcommittee E-10.08, Procedures for Neutron Radiation Damage Simulation, of the American Society for Testing and Materials.

Richard J. Beaver was appointed Chairman of Committee E-46 of the American Society for Testing and Materials by the Executive Committee.

Appendix E Seminar Program

Since good communication is vital to technological advance, the Division sponsors and maintains an active seminar program to promote exchange of ideas and discussion of common problems among researchers working in the field of materials science and technology and allied disciplines. Most of the talks deal with scientific and engineering subjects and are presented by invited speakers from various organizations located in the United States and abroad. The actual number of talks scheduled in any given week varies, but over the full year it averages about two per week.

The Seminar Program is administered by a committee appointed by Division management. The Seminar Committee for calendar years 1980 and 1981 consists of D. O. Hobson (Chairman), N. H. Packan, and G. C. Wei.

The speakers and topics of seminars presented during the past year are listed below. It is interesting to note that 16 of the 98 talks scheduled were made by individuals affiliated with institutions located outside the United States. An alternate breakdown indicates 41 talks by university faculty members and graduate students, 9 by representatives from industrial firms, and the balance from governmental and other research institutions. In function, the program achieves the desired objectives of maintaining intimate relations with the university community and in enhancing diffusion of knowledge.

M. J. Bennett (AERE, Harwell, England), "Ion Implantation and Ion Beam Analysis in Metal Oxide Studies" (July 2, 1979).

S. M. Copley (University of Southern California), "Nonequilibrium Processing With a CO_2-CW Laser" (July 10, 1979).

P. G. Klemens (University of Connecticut), "Theory of the Lattice Thermal Conductivity at Elevated Temperatures" (July 11, 1979).

Anna Sarosiek (Massachusetts Institute of Technology), "Fatigue Crack Propagation of High-Strength Low-Alloy Steels" (July 11, 1979).

Gene E. Ice (University of Oregon), "X-Ray Scattering by Low Z Gases and Precision Measurement of Rare Gas Binding Energies With Synchrotron Radiation" (July 12, 1979).

R. Bullough (AERE, Harwell, England), "The Modeling of Evolving Microstructure in Irradiated Material" (July 19, 1979).

James J. Wert (Vanderbilt University), "The Advantages of SHaRE Program Research for Universities" (July 24, 1979).

R. A. Vandermeer (Metals and Ceramics Division, ORNL), "Much Ado About Nothing, or Annealing of Voids in Irradiated Aluminum" (July 27, 1979).

Daniel Kramer (Rutgers University), "Cation Release Behavior From Alkali Silicate Glasses" (August 2, 1979).

M. Baron (Westinghouse Electric Corporation), "Trapping, Segregation, and Effects on Void Swelling" (August 2, 1979).

John Manning (National Bureau of Standards), "Basic Mechanisms of Diffusion" (August 2, 1979).

S. Rothman (Argonne National Laboratory), "Swelling in Dilute Alloys of Niobium" (August 3, 1979).

S. Rothman (Argonne National Laboratory), "Partial Diffusion Coefficients in Iron-Chromium-Nickel Alloys" (August 3, 1979).

K. C. Russell (Massachusetts Institute of Technology), "Void Nucleation in the Presence of Gases and Solutes" (August 3, 1979).

J. W. Steeds (University of Bristol, England), "Precipitate Identification in Steels Using Convergent Beam Electron Diffraction" (August 10, 1979).

B. L. Gyorffy (University of Bristol, England), "The Possibility of Superconductivity in Palladium-Silver Alloys" (August 15, 1979).

Himanshu Jain (Columbia University), "Point Defects in Alpha Quartz" (August 16, 1979).

J. S. Faulkner (Metals and Ceramics Division, ORNL), "Recent Developments in Linearized Band Theory" (August 24, 1979).

A. Habenschuss (Chemistry Division, ORNL), "The Hydration of Rare Earth Ions in Aqueous Solutions From X-Ray Diffraction and Thermodynamics" (August 28, 1979).

Erland M. Schulson (Dartmouth College), "Microstructure and Mechanical Properties of Ordered Zr_3Al" (August 30, 1979).

James M. Martin (Huntington Alloys, Inc.), "Materials for SO_2 Desulfurization Equipment" (August 31, 1979).

J. D. Ayers (Naval Research Laboratory), "Laser Remelt Consolidation of Plasma-Sprayed Coatings" (September 4, 1979).

P. L. Cowan (Bell Laboratories), "X-Ray Standing Waves at Crystal Surfaces – A New Surface Structure Probe" (September 4, 1979).

Peter L. Fejes (Cornell University), "Electron Energy Loss Studies of Si and SiO_2" (September 10, 1979).

John M. Vitek (Olin Corporation, New Haven, Connecticut), "Characterization of Amorphous Copper-Zirconium Alloys" (September 12, 1979).

R. L. Mills (Ohio State University), "Gauge Field Theories for the Uninitiated" (September 12, 1979).

J. F. Harris (KFA, Jülich, West Germany), "The English Nuclear Scene and a Bit More About the Parthenon" (September 14, 1979).

J. C. Swihart (Indiana University), "The Electron-Phonon Interaction and Electromagnetic Absorption in Metals" (September 21, 1979).

Steven Garwood (British Welding Institute, Cambridge, England), "Ductile Crack Growth Considerations in Fracture Assessment Procedures" (September 24, 1979).

George H. Bishop (Army Materials and Mechanics Research Center, Watertown, Massachusetts), "Grain Boundary Sliding and Migration as Observed in a Computer Molecular Dynamics Simulation" (September 25, 1979).

Brian Ralph (Royal Microscopical Society, Cambridge, England), "The Structures of Grain Boundaries and the Properties Associated with Them" (September 25, 1979).

Scott Liu (University of Cincinnati), "Materials Research in the Areas of Radiation Effects on Molybdenum and High-Temperature, Low-Cycle Fatigue of Nickel-Base Superalloys" (September 26, 1979).

R. W. Carpenter (Metals and Ceramics Division, ORNL), "New Analytical Technique Associated with Transmission Electron Microscopy" (October 2, 1979).

Dale Koelling (Argonne National Laboratory), "How Well Does a Band Calculation Describe a Fermi Surface – Case Studies From the Group VA and Platinum Group Metals" (October 3, 1979).

S. D. Dahlgren (Battelle Pacific Northwest Laboratory), "Fabrication of Metallic Glasses by High-Rate Sputter Deposition" (October 9, 1979).

Paul F. Becker (Naval Research Laboratory, Washington, D.C.), "Thermal Shock and Fracture Behavior of Ceramics" (October 22, 1979).

Che-Yu Li (Cornell University), "Cavity Growth on Grain Boundaries" (October 25, 1979).

Che-Yu Li (Cornell University), "Modeling of Transient Deformation" (October 26, 1979).

C. C. Koch (Metals and Ceramics Division, ORNL), "Trip Report to Germany in September" (October 26, 1979).

J. P. Moore (Metals and Ceramics Division, ORNL), "A Year at Kernforschungzentrum" (October 26, 1979).

K. Scharnberg (Ames Laboratory and Hamburg University, West Germany), "Special Phonons and Superconductivity in the Hexagonal Tungsten Bronzes" (October 30, 1979).

T. J. Hakkarainen (Cornell University), "The Microstructure of a Ferritic Stainless Steel at Elevated Temperature" (October 30, 1979).

D. K. Saldin (Oxford University, England), "Electron Microscope Image Contrast Simulation Theory for Tetrahedra, Voids, and Loops" (October 30, 1979).

E. Z. deSilva (Bristol University, England), "Superconducting Fluctuations $(SN)_x$" (October 31, 1979).

Peter Humble (CSIRO, Division of Chemical Physics, Clayton, Victoria, Australia), "Image Simulation of Defects in Crystalline Solid" (November 5, 1979).

J. S. Langer (Carnegie-Mellon University), "Kinetics of Phase Separations" (November 7, 1979).

N. H. Packan (Metals and Ceramics Division, ORNL), "On the Validity of Helium Preinjection in Radiation Damage Simulation" (November 9, 1979).

W. Kesternich (KFA, Jülich, West Germany), "Helium Cavitation and its Relation to TiC Precipitation in an Alpha-Irradiated Stainless Steel" (November 9, 1979).

J. R. Weertman (Northwestern University), "Small-Angle Neutron Scattering Study of Grain Boundary Cavitation in High-Purity Copper Fatigued at Elevated Temperatures" (November 15, 1979).

Robin O. Williams (Metals and Ceramics Division, ORNL), "Spinoidal Decomposition" (November 15, 1979).

R. Wang (Battelle Pacific Northwest Laboratory), "Thermal Stability and Short-Range Structure of Noncrystalline Elemental Solids and Binary Intertransition Metal Alloys" (December 3, 1979).

Walter Kohn (Institute for Theoretical Physics), "A Universal Model for the Surface Energy of Solids" (December 5, 1979).

D. M. Kroeger (Metals and Ceramics Division, ORNL), "A Study of Arc-Hammer Speeds and Critical Cooling Rates in Amorphous Transition Metal Alloys" (December 7, 1979).

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C. Cline (Lawrence Livermore Laboratory), "High-Rate Consolidation of Metallic Glasses and Ceramics" (January 22, 1980).

L. L. Boyer (Naval Research Laboratory, Washington, D.C.), "Parameter-Free Equation of State Calculations for Ionic Materials" (January 30, 1980).

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T. S. Lundy (Metals and Ceramics Division, ORNL), "Confessions of a Program Manager" (February 1, 1980).

Paul Grobner (Climax Molybdenum Company, Ann Arbor, Michigan), "Chemical Properties of 9 to 12 Chrome Steels" (February 5, 1980).

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J. K. Hirvonen (Naval Research Laboratory), "Applications of Ion Implantation in Tribology and Corrosion Science" (March 11, 1980).

W. D. Nix (Stanford University), "Role of Long-Range Internal Stress in Power Law Creep and Power Law Breakdown" (March 12, 1980).

Jacques Giovanola (University of California, Berkeley), "The J-Integral as a Fraction Parameter and Some Experimental Results" (March 24, 1980).

C. L. White (Metals and Ceramics Division, ORNL), "Studies of Grain Boundary Phenomena in Iridium Using Auger Electron Spectroscopy" (March 28, 1980).

Warren M. Garrison (University of California, Berkeley), "The Effect of Silicon and Aluminum Additions on the Mechanical Properties and Microstructures of Secondary Hardening Steels" (March 30, 1980).

Alan Wolfenden (Westinghouse Corporation), "Internal Friction at 40 kHz for Monitoring Metallurgical Changes" (March 31, 1980).

T. W. Barbee (Stanford University), "Synthesis of Metastable Alloy Structures by Physical Vapor Deposition – Sputtering" (April 1, 1980).

Julia Weertman (Northwestern University), "Fatigue-Induced Cavitation in Single-Phase Materials" (April 3, 1980).

T. F. Edgar (University of Texas), "In situ Gasification of Coal" (April 7, 1980).

H. S. Yoder, Jr. (Geophysical Laboratory, Carnegie Institution of Washington), "Experimental Determination of Transport Properties of Magma at High Pressure and Temperature" (April 10, 1980).

V. J. Tennery (Metals and Ceramics Division, ORNL), "Fundamental Needs in Structural Ceramics" (April 11, 1980).

Roger Taylor (National Research Council, Canada), "The Calculation of Vacancy Formation and Self-Diffusion Energies in Simple Metals" (May 7, 1980).

H. L. Yakel (Metals and Ceramics Division, ORNL), "Crystallography at Synchrotron Radiation Sources" (May 9, 1980).

Fred Dworschak (KFA-Jülich, West Germany), "Damage Rate Measurements as a Means to Study Interstitial Clusters" (May 19, 1980).

P. S. Sklad (Metals and Ceramics Division, ORNL), "Phase Identification in Structural Ceramics" (May 23, 1980).

W. S. Williams (University of Illinois), "Properties of Transition of Metal Carbides" (May 27, 1980).

S. K. Tyler (University of Surrey, England), "Helium Bubbles in Refractory Metals" (May 29, 1980).

J. D. McGervey (Case Western Reserve University), "A New Dimension in Studies of Materials by Positron Annihilation" (June 2, 1980).

S. H. Vosko (University of Toronto), "Accurate Spin-Dependent Electron Correlation Energies: Some Consequences in LSDA Calculations" (June 4, 1980).

B. C. Giessen (Northeastern University), "Recent Developments in the Alloying Behavior of Metallic Glasses" (June 6, 1980).

C. S. Yust (Metals and Ceramics Division, ORNL), "Explosive Compaction of Ceramic Powders" (June 6, 1980).

H. W. Kerr (University of Waterloo, Canada), "Microstructure and Toughness of Submerged-Arc Welds in Pipeline Steels" (June 10, 1980).

Timothy Reiley (Metals and Ceramics Division, ORNL), "Irradiation Creep Using Jülich Light Ions . . . and More" (June 13, 1980).

J. T. Stringer (Electric Power Research Institute), "Materials Problems in Fluidized Bed Combustion Systems" (June 17, 1980).

Alan Atkinson (AERE, Harwell, England), "Measurements of Short Circuit Diffusion Coefficients in Nickel Oxide and Their Relevance to the Oxidation of Nickel" (June 18, 1980).

Peter Haasen (University of Göttingen), "Hardening Mechanisms for Mechanical Properties, Superconductivity, and Ferromagnetism" (June 20, 1980).

L. K. Mansur (Metals and Ceramics Division, ORNL), "Understanding Results of Dual Beam Swelling Experiments or More Gas Pains" (June 20, 1980).

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Appendix F Advisory Committee

The Advisory Committee to the Metals and Ceramics Division currently consists of seven members appointed by the Laboratory Director, and plans call for enlarging the size of the Committee to eight members in 1981. Members are appointed for a four-year term on a staggered basis so that two new members replace two members retiring from service each year. The main function of the Committee is to review ongoing research and development activities and render an independent judgment on the general state and welfare, ability of staff, and progress being made in various operations and missions of the Division. Members are drawn from governmental, industrial, educational, and research institutions in the United States and are selected on the basis of demonstrated ability in management, research, and technology. Members of the 1980 Advisory Committee are listed below.

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Appendix G Publications

Compiled by Alice Rice

L. Adler, D. Fitting, J. Lattimer, and A. L. Wright, *Development of an Ultrasonic Imaging System to Measure the Size and Velocity of Large Bubbles Rising Through Liquids,* NUREG/CR-1122, ORNL/NUREG/TM-364 (April 1980).

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C. R. Kennedy, *Graphite Having Improved Thermal Stress Resistance and Method of Preparation* (to U.S. Department of Energy). U.S. Patent 4,190,637. February 26, 1980.

C. T. Liu and H. Inouye, *Ductile Long Range Ordered Alloys with High Critical Ordering Temperature and Wrought Articles Fabricated Therefrom* (to U.S. Department of Energy). U.S. Patent 4,144,059. March 13, 1979.

Appendix H Presentations at Technical Meetings

Compiled by Alice Rice

12th Annual International Metallographic Society Meeting, Tamiment, Pennsylvania, July 8–11, 1979.

D. A. Canonico, R. S. Crouse,* and T. J. Henson, "A Fractographic Study of a Thick Wall Pressure Vessel Failure."

R. J. Gray,* G. M. Slaughter, J. C. Griess, and C. W. Houck, "Metallurgical Analysis of Fire-Damaged Piping from a U. S. Strategic Petroleum Reserve Supply Facility."

G. M. Slaughter,* "Metallography as a Quality Control Tool – Welding and Brazing."

US/USSR Breeder Reactor Core Materials Information Exchange Meeting, Hanford Engineering Development Laboratory, Richland, Washington, July 30–31, 1979.

A. F. Rowcliffe,* E. H. Lee, and P. S. Sklad, "Charged Particle Irradiation in the United States Breeder Reactor Program."

American Crystallographic Association Meeting, Boston, Massachusetts, August 12–17, 1979.

C. J. Sparks, Jr.,* "Applications of Solid State Detectors to X-Ray Scattering Measurements: Background Reduction and Unique Information."

R. W. Hendricks, J. M. Schultz, J. S. Lin,* J. Peterman, and R. M. Gohil, "Annealing of Polypropylene Films Crystallized from a Highly Extended Melt."

J. E. Epperson,* J. Faber, R. W. Hendricks, and J. S. Lin, "Small-Angle Scattering Observations of a Decomposing Ni–Al Alloy."

R. W. Hendricks, J. S. Lin,* J. M. Schultz, and R. G. Nepler, "Temperature-Dependent Small-Angle X-Ray Scattering from Poly(Vinylidene Fluoride)."

R. W. Hendricks, "Small-Angle Scattering Observations of a Decomposing Ni-Al Alloy."

37th Annual Meeting of the Electron Microscopy Society of America (EMSA), San Antonio, Texas, August 13–17, 1979.

J. Bentley* and R. W. Carpenter, "The Dependence of Secondary Electron Image Contrast of Periodic Objects Upon Probe Diameter."

D. N. Braski and J. T. Houston,* "Improved TEM Specimen for Semiautomatic Jet Polishing."

R. W. Carpenter* and E. A. Kenik, "The Effect of Displacement Cascades on Chemical Order in Ni_4Mo."

E. A. Kenik,* B. R. Livesay, and R. W. Carpenter, "High-Voltage Electron Microscopy Studies of Hydrogen Storage Materials."

E. A. Kenik,* K. R. Lawless, and R. W. Carpenter, "High-Voltage Electron Microscopy In-Situ Oxidation Research on Vanadium and Vanadium-Titanium."

D. N. Braski,* R. W. Carpenter, and E. A. Kenik, "Discontinuous Precipitation in Ordered $(FeCo)_3V$ Alloys."

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*Speaker.

Fifth International Conference on Structural Mechanics in Reactor Technology, Berlin, Germany, August 13–17, 1979.

F. W. Wiffin,* "The Change of Material Properties During Irradiation in Fusion Reactor Service."

W. R. Corwin,* "Fatigue Crack Propagation in 2¼ Cr-1 Mo Steel."

Seminar, AERE Harwell, England, August 16, 1979.

M. H. Yoo,* "The Role of Divacancies in Loop Growth and Void Swelling."

International Cryogenic Materials Conference, Madison, Wisconsin, August 21–24, 1979.

D. S. Easton, W. Specking,* and P. A. Sanger, "Stress Effects in an Nb_3Sn Conductor Proposed for use in the Magnetic Fusion Energy Program."

Fifth International Conference on Strength of Metals and Alloys, Aachen, FRG, August 27–31, 1979.

M. H. Yoo,* "A Dislocation Model for Twinning and Fracture and Its Application to H.C.P. Metals."

KFA, Jülich, FRG, September 3, 1979.

M. H. Yoo,* "A Generalized Rate Theory Model of Void Swelling."

Symposium on Eddy Current Characterization of Materials and Structures, Gaithersburg, Maryland, September 5–7, 1979.

C. V. Dodd* and W. E. Deeds, "In-Service Inspection for Steam Generator Tubing Using Multiple Frequency Techniques."

Centre D'Études Nucléaires de Saclay, France, September 6, 1979.

M. H. Yoo,* "Growth Kinetic of Dislocation Loops and Voids."

University of Paris-Sud, Centre D'Orsay, France, September 7, 1979.

M. H. Yoo,* "Slip, Twinning and Fracture in H.C.P. Metals."

Symposium on Rare Gases in Metals and Ionic Solids, AERE, Harwell, England, September 10–14, 1979.

K. Farrell,* "Experimental Observations of Effects of Inert Gases on Cavity Formation."

American Society for Metals, Bluegrass Chapter, Lexington, Kentucky, September 12, 1979.

S. A. David,* "Solidification Behavior of Austenitic Stainless Steel Filler Metals."

AIME Fall Meeting, Milwaukee, Wisconsin, September 16–20, 1979.

J. D. Holder* and G. W. Clark, "Synthesis of Oxide-Metal Eutectic Composites by Improved IZG and Skull-Melting Techniques."

P. F. Tortorelli,* J. H. DeVan, J. R. DiStefano, and R. L. Klueh, "Compatibility of Refractory Metals with Lithium in a Fusion Reactor Environment."

C. L. White,* J. R. Keiser, "Boron Segregation to Grain Boundaries and Improved Ductility in Pt–30 wt % Rh–8 wt % W."

J. L. Scott,* "Requirements for Refractory Metals in the Fusion Environment."

M. H. Yoo,* "The Competitive Role of Deformation Twinning Against Cleavage Fracture."

H. Inouye* and C. T. Liu, "Environmental Effects on Mechanical Properties of Refractory Metal Alloys."

J. M. Leitnaker, J. Bentley,* and Said Izadi, "Comparative Rates of Precipitation in Cast and Wrought Structures."

D. S. Easton* and W. Specking, "The Effect of Copper Stabilization on the Strain Behavior of Nb_3Sn Multi-filamentary Conductors."

D. M. Kroeger,* D. S. Easton, A. DasGupta, J. O. Scarbrough, and C. C. Koch, "The Effect of Stress Upon the Scaling Law for Flux Pinning in Bronze Process Nb_3Sn."

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*Speaker.

C. C. Koch, A. DasGupta,* D. M. Kroeger, and J. O. Scarbrough, "The Peak Effect, Summation Problem, and Magnetic History in a Superconducting Nb–38 at. % Hf Alloy."

A. DasGupta,* "Flux Pinning by Grain and Phase Boundaries."

R. O. Williams,* "The Modification of Phase Diagrams by Coherency."

M. B. Lewis,* "Nondestructive Techniques for the Measurement of Oxygen and Hydrogen Profiles Near Metal Surfaces."

Third Europhysics Topical Conference on Lattice Defects in Ionic Crystals, Canterbury, England, September 17–21, 1979.

R. A. McKee* and A. B. Lidiard, "Kinetics and Thermodynamics of the Migration of Interstitial Defects."

Seminar, Lawrence Livermore Laboratory, California, September 20–21, 1979.

R. A. Vandermeer,* "A Report on Recent Studies of Phase Transformations and Shape Memory Effects (SME) in Uranium-Niobium Alloys."

Information Meeting, HEDL, Richland, Washington, September 25–27, 1979.

E. H. Lee and A. F. Rowcliffe,* "The Effects of Thermomechanical Treatment of Phase Stability and Swelling in Alloy D9."

P. S. Sklad,* "Phase Stability and Swelling in the V-Series Alloys."

Seminar for Department of Metallurgy, University of Connecticut, Storrs, Connecticut, September 26, 1979.

A. DasGupta,* "Some Aspects of Flux Pinning by Grain Boundaries and Precipitates in Superconductors."

26th National AVS Symposium, New York, October 2–5, 1979.

R. E. Clausing,* L. C. Emerson, H. L. Heatherly, Jr., T. C. Domm, R. A. Langley, and J. E. Simpkins, "A Six-Inch Diameter U.H.V. Transfer System for Remote Plasma-Wall Interaction Experiments."

Midwest Solid State Theory Conference, Columbus, Ohio, October 8–9, 1979.

J. S. Faulkner,* "Calculating Properties With the Coherent-Potential Approximation."

Poster Session, American Physical Society, Columbus, Ohio, October 8–9, 1979.

F. J. Pinski, P. B. Allen, W. H. Butler, and J. S. Faulkner, "Electrical and Thermal Resistivities: Solutions to the Boltzmann Equation for Electrons in Metals."

Fourth Annual Conference on Materials for Coal Conversion and Utilization, Gaithersburg, Maryland, October 9–11, 1979.

V. K. Sikka, "Potential use of Modified 9 Cr-1 Mo Steel for Fossil Utility Boiler Applications." (presented by R. A. Bradley)

J. H. DeVan* and T. G. Godfrey, "Heat Exchanger Materials for Fluidized-Bed Coal Combustors."

G. M. Goodwin, "Fossil Energy Welding and Cladding Program." (presented by R. A. Bradley)

G. W. Brassell* and V. J. Tennery, "Technology Assessment of Ceramic Joining Applicable to Heat Exchangers."

V. J. Tennery, G. W. Brassell,* G. W. Weber, and G. C. Wei, "Materials and Application Studies for Ceramic Recuperators (Heat Exchangers)."

Buffalo/Niagara Falls Chapter of the American Society for Metals, Tonawanda, New York, October 11, 1979.

R. J. Gray,* "New and Unusual Techniques in Metallography."

American Ceramic Society Fall Meeting, New Orleans, Louisiana, October 14–17, 1979.

H. Cords,* G. Krauss, and R. Zimmermann, "Fracture Criterion for Brittle Materials Based on Finite Statistical Cells."

H. Cords* and R. Zimmermann, "A Modified Strain-Energy Approach for Calculating Multiaxial Strengths."

*Speaker.

P. Angelini,* R. W. Carpenter, and D. P. Stinton, "High-Resolution Analytical Electron Microscopy Analysis of Synroc Nuclear Waste Storage Material."

G. C. Wei,* "Phase Transformation and Processing of Polycrystalline Gadolinium Selenide."

C. L. Hoenig* and C. S. Yust, "Explosive Compaction and Microstructural Analysis of AlN, Amorphous Si_3N_4, Boron, and Al_2O_3 Ceramics."

A. J. Caputo* and R. R. Suchomel, "Current Status of Process and Equipment for Loading Full-Length Fuel Pins Using Gel-Sphere-Pac Technology."

R. R. Suchomel* and M. H. Lloyd, "Sintering Studies of Gel-Derived $(U,Pu)O_2$ Microspheres."

S. M. Tiegs,* J. B. Strand, and S. J. Yosim, "Incineration Methods for Disposal of Organic Wastes from HTGR Fuel Refabrication Processes."

D. P. Stinton* and R. D. Spence, "Sintering of Gel-Derived $UO_3 + C$ to Produce Highly Dense $UO_2 + UC_2$ Microspheres."

J. E. Mack* and D. P. Stinton, "Effects of Pneumatic Conveying on Gel-Derived Nuclear Fuel Microspheres."

J. H. Smith,* "A Study of Ultrasonic Calibration Reflectors for Stainless Steel Weld Evaluation."

J. Lattimer, D. W. Fitting,* and L. Adler, "An Ultrasonic Dynamic Imaging (UDI) System to Determine the Size and Velocity of Large Spherical Simulated Bubbles in Liquid."

NBS–DOE Workshop on Materials at Low Temperatures, Vail, Colorado, October 16–18, 1979.

C. J. Long,* "The Large Coil Program: Current Status."

C. J. Long,* R. R. Coltman, Jr., C. E. Klabunde, and R. H. Kernohan, "Radiation Effects on Organic Insulators for Superconducting Magnets: 1×10^{10} rad at 5 K."

Appalachian Regional Electron Microscopy Society Fall Meeting, East Tennessee State University, October 19, 1979.

J. Bentley,* "Analytical Electron Microscopy."

University of Tennessee, October 23, 1979.

W. A. Coghlan,* "A Collection of Technical Highlights from Visits to Laboratories in France, Germany, and Poland."

Seminar at College of Engineering, Vanderbilt University, Nashville, Tennessee, October 24, 1979.

R. W. Carpenter,* "Analytical Electron Microscopy and Modern Materials Science Research."

Geological Society of America National Meeting, San Diego, California, November 5–8, 1979.

H. E. Barrett, O. C. Kopp,* and L. A. Harris, "A Study of Elemental and Maceral Distribution in Coals of Different Paleoenvironments."

16th International Thermal Conductivity Conference, Chicago, Illinois, November 7–9, 1979.

R. S. Graves, R. K. Williams, and J. P. Moore,* "The Thermal Conductivity, Electrical Resistivity and Seebeck Coefficient of SRM-735."

D. L. McElroy,* R. K. Williams, F. J. Weaver, and R. S. Graves, "The Physical Properties of $V(Fe,Co,Ni)_3$ Alloys from 300 to 1000 K."

D. W. Yarbrough,* R. K. Williams, and R. S. Graves, "Transport Properties of Concentrated Ag-Pd and Cu-Ni Alloys from 300–1000 K."

American Nuclear Society Winter Meeting, San Francisco, November 11–19, 1979.

J. E. Mack,* P. Angelini, and R. R. Suchomel, "Development of Nuclear Fuel Microsphere Handling and Equipment."

N. H. Packan* and K. Farrell, "On the Validity of Helium Preinjection in Radiation Damage Simulation."

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*Speaker.

C. R. Kennedy,* W. P. Eatherly, and M. F. O'Connor, "The Results of Irradiation Testing of German Graphites in the HFIR."

S. M. Tiegs* and D. P. Stinton, "Examination of the Carbothermic Conversion Process for UO_2-UC_2-C Fuel Microspheres."

E. J. Allen,* J. E. Rushton, M. M. Chiles, and J. D. Jenkins, "Evaluation of a Nondestructive Assay Technique for On-Line Assay of Fuel Rods in an HTGR Fuel Refabrication Plant."

S. M. Tiegs* and P. A. Haas, "Improved Fuel Pellet Fabrication Using GEL Microspheres."

H. Nabielek, Ling Yang, and F. J. Homan,* "Performance Aspects of Low-Enriched Oxide Fuel for HTRs."

F. J. Homan* and O. M. Stansfield, "Design and Qualification of a Proliferation Resistant Fuel for the HTGR."

J M Robbins, M. J. Kania, E. L. Long, Jr.,* and W. T. Rainey, "A System for Measuring Fission-Gas Inventories of HTGR Fuel Particles."

R. L. Senn* and M. M. Martin, "A Test Bed for High-Uranium-Loaded Fuel Plates."

Eighth Symposium on Engineering Problems in Fusion Energy, San Francisco, November 13–16, 1979.

P. F. Tortorelli,* J. H. DeVan, and J. E. Selle, "Corrosion Inhibition in Lithium/Nickel-Bearing Alloy Systems."

24th Annual Conference on Magnetism and Magnetic Materials, Cleveland, Ohio, November 14–18, 1979.

W. C. Koehler and R. W. Hendricks,* "The United States National Small-Angle Neutron Scattering Facility."

Materials Engineering Graduate Seminar, VPI, Blacksburg, Virginia, November 15, 1979.

J. D. Holder,* "Preparation of High-Temperature Oxide-Metal Eutectic Composites: A Review."

ORAU Visiting Lecture Program, North Carolina State University, November 20, 1979.

J. Bentley,* "Analytical Electron Microscopy."

Colloquium Series, Case Western Reserve University, Cleveland, Ohio, November 20, 1979.

R. W. Carpenter,* "Convergent-Beam Diffraction: Applications and Instrumentation."

Symposium on Fractography in Materials Science, Williamsburg, Virginia, November 25–30, 1979.

D. A. Canonico* and R. S. Crouse, "Post-Test Fractographic Analysis of Heavy Section Steel Technology Pressure Vessel Tests."

Second Japanese Institute of Metals International Symposium on Hydrogen in Metals, Minakami Spa, Japan, November 26–29, 1979.

E. A. Kenik* and B. R. Livesay, "In-Situ Hydriding of Hydrogen Storage Materials."

Materials Research Society Meeting, Boston, Massachusetts, November 26–30, 1979.

L. A. Harris and C. S. Yust,* "TEM Characterization of Coals."

D. M. Kroeger,* C. C. Koch, D. S. Easton, and J. O. Scarbrough, "A Study of Arc-Hammer Speeds and Critical Cooling Rates in Amorphous Transition Metal Alloys."

C. C. Koch,* B. C. Giessen, D. M. Kroeger, and J. O. Scarbrough, "Superconductivity in Amorphous Equielectronic Transition Metal Alloys."

Seminar at Stanford University, November 28, 1979.

W. A. Coghlan,* "Growth of Interstitial Loops Under HVEM Irradiation."

ASTM-ASME-MPC Joint Committee J-1 ASME Winter Meeting, New York, December 3, 1979.

R. W. Swindeman,* "Relaxation Response After Monotonic and Cyclic Strain."

Seminar at Vanderbilt University, Nashville, Tennessee, December 5, 1979.

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

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*Speaker.

U.S./Japan Fusion Cooperation Program, Symposium on Effects of Fusion Environment on Materials, Argonne National Laboratory, January 7–10, 1980.

F. W. Wiffen,* "Neutron Irradiation Effects in BCC Refractory Metal Alloys."

E. E. Bloom,* "Swelling and Mechanical Property Changes at Fusion Reactor Damage Levels."

ORAU Visiting Lecture Program, University of Kentucky, January 16, 1980.

J. Bentley,* "Analytical Electron Microscopy."

ASM Seminar, Oak Ridge, Tennessee, January 17, 1980.

R. W. Carpenter,* "Analytical Electron Microscopy Techniques and Developments."

Energy-Sources Technical Conference and Exhibition, New Orleans, February 3–7, 1980.

V. B. Baylor* and J. H. DeVan, "Materials Performance in Coal Liquefaction Pilot Plants."

Seminar, Rockwell Science Center, Thousand Oaks, California, February 18, 1980.

R. W. Carpenter,* "Analytical Electron Microscopy: Electron Energy Loss Spectroscopy and Convergent-Beam Diffraction for Phase Identification."

WATTec Conference, Knoxville, Tennessee, February 20–22, 1980.

R. W. McClung,* "NDT Development at ORNL – 1980."

Seminar at MIT, Cambridge, Massachusetts, February 22, 1980.

C. L. White,* "Grain Boundary Segregation and Its Effect on High-Temperature Ductility in Ir–0.3% W."

AIME Annual Meeting, Las Vegas, Nevada, February 24–28, 1980.

L. A. Harris* and C. S. Yust, "A Review of Advanced Coal Petrographic Methods in Characterizing and Assessing Coals for Utilization."

W. A. Coghlan,* "The Effect of Applied Stress on the Sink Efficiency of Finite Frank Loops."

C. T. Liu,* "Yield Stress of Ductile Ordered Alloy Co–16.3% Fe–22.6% V $[(Fe_{22}Co_{78})_3V]$ at Room and Elevated Temperatures."

V. B. Baylor and J. R. Keiser,* "Corrosion in Fractionating Towers at Coal Liquefaction Pilot Plant."

V. B. Baylor* and J. R. Keiser, "Stress Corrosion Cracking in Coal Liquefaction Systems."

R. A. Vandermeer* and J. C. Ogle, "The Kinetics of Void Annealing in Neutron-Irradiated Aluminum."

R. W. Carpenter,* "Applications of Microdiffraction to Phase Transformation Research and Lattice Defect Identification in Solids."

N. J. Zaluzec* and R. W. Carpenter, "Light Element Analysis in Structural Alloys and Ceramics by Electron Energy Loss Spectroscopy."

S. A. David* and D. N. Braski, "Solidification Behavior of Austenitic Stainless Steel Filler Metal."

C. L. White* and C. T. Liu, "Grain Boundary Segregation in Ir–0.3% W Alloys."

C. T. Liu,* H. Inouye, C. L. White, and A. C. Schaffhauser, "Mechanical Properties and Thorium Segregations to Grain Boundaries in Ir–0.3% W Alloys."

J. Bentley,* "Analytical Electron Microscopy Using a Field Emission Gun."

J. S. Lin,* R. W. Hendricks, J. Bentley, and F. W. Wiffen, "Small-Angle X-Ray Scattering Study on Neutron-Irradiation Effects in Molybdenum and Molybdenum Alloys."

G. R. Gessel* and C. L. White, "Use of AES and RGA to Study Neutron Irradiation Enhanced Segregation to Internal Surfaces."

R. W. Hendricks,* "The Use of Small-Angle X-Ray and Neutron Scattering for Characterizing Voids in Neutron-Irradiated Metals and Alloys."

M. B. Lewis* and K. Farrell, "Nuclear Microanalysis as a Probe of Impurity-Defect Interactions."

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*Speaker.

E. A. Kenik,* K. R. Lawless, and R. W. Carpenter, "Low Pressure in Situ Oxidation of Vanadium and V–20% Ti."

National Association of Corrosion Engineers Meeting, Chicago, Illinois, March 3–7, 1980.

J. A. Beavers,* J. C. Griess, and W. K. Boyd, "Stress Corrosion Cracking of Zirconium in Nitric Acid."

Metallurgical and Materials Engineering Department, Illinois Institute of Technology, Seminar, Chicago, Illinois, March 6, 1980.

R. A. Vandermeer,* "The Kinetics of Void Annealing in Neutron-Irradiated Aluminum."

Waste Management 80, University of Arizona, Tucson, Arizona, March 10–14, 1980.

W. J. Lackey,* P. Angelini, F. L. Layton, D. P. Stinton, and J. S. Vavruska, "Sol–Gel Technology Applied to Glass and Crystalline Ceramics."

G. L. Copeland* and R. L. Heestand, "Volume Reduction of Contaminated Metal Waste."

Seminar, University of Virginia, Charlottesville, Virginia, March 17, 1980.

R. W. Carpenter,* "High-Resolution Electron Diffraction Methods in Analytical Electron Microscopy."

Second DOE Environmental Control Symposium, Reston, Virginia, March 17–19, 1980.

V. J. Tennery,* E. S. Bomar, W. D. Bond, L. E. Morse, H. R. Meyer, J. E. Till, and M. G. Yalcintas, "Environmental Impact of Radioactive Releases from Recycle of Thorium-Based Fuel Using Current Containment Technology."

American Crystallographic Association Winter Meeting, Gulf Shores, Alabama, March 17–21, 1980.

R. W. Hendricks* and W. C. Koehler, "The National Center for Small-Angle Scattering Research."

American Society for Nondestructive Testing Spring Conference, Philadelphia, Pennsylvania, March 24–27, 1980.

K. V. Cook,* L. Adler, R. K. Nanstad, and S. Golan, "Measurement of Fatigue Crack Profile in Steel Using an Ultrasonic Diffraction Technique."

B. E. Foster, R. W. McClung,* and E. V. Davis, "Relationship Between Penetrameter Sensitivity and Crack Detectability for Several Thicknesses of Steel as Radiographic Parameters are Varied."

American Physical Society, New York, March 24–28, 1980.

A. Gonis and G. M. Stocks,* "Total and Component Densities of States in the KKR-CPA and Average t-Matrix Approximation."

G. M. Stocks* and B. L. Gyorffy, "Momentum Distribution of Electrons in Random Alloys: The Fermi Surface of $Ag_cPd_{(1-c)}$ Alloys."

J. S. Faulkner* and G. M. Stocks, "New Formulas for Calculating Properties with the KKR-CPA: Algebraical."

G. M. Stocks* and J. S. Faulkner, "New Formulas for Calculating Properties with the KKR-CPA: Numerical."

L. A. Boatner,* G. W. Beall, M. M. Abraham, C. B. Finch, P. G. Huray, and M. Rappaz, "The Growth and Characterization of Actinide-Doped Lanthanide Orthophosphate Single Crystals."

S. Suehiro* and R. W. Hendricks, "Dynamic Deformation Device for Small-Angle X-Ray and Neutron Scattering."

R. W. Hendricks and W. C. Koehler,* "The National Center for Small-Angle Scattering Research – A Progress Report."

R. A. McKee,* "Phenomenological Coefficients for Interstitial Diffusion in a Dilute Two-Component System."

D. M. Kroeger,* D. S. Easton, C. C. Koch, A. DasGupta, and J. O. Scarbrough, "Evidence for Microstructural Changes Under Strain in Bronze Process Nb_3Sn."

F. J. Pinski,* "Solutions to the Boltzmann Equation for Electrons in a Metal: Energy Dependence."

T. P. Beaulac,* P. B. Allen, and F. J. Pinski, "Calculation of the Low-Field Hall Coefficient in Cu and Nb."

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F. J. Pinski, F. S. Kahn, and W. H. Butler,* "Calculation of the Anisotropic Electron-Phonon Mass Enhancement in Cu and Nb."

W. H. Butler,* "Upper Critical Field of Pure Nb: Calculated Temperature Dependence and Anisotropy."

G. M. Stocks* and W. H. Butler, "Residual Resistivity of Ag Pd Alloys."

A. DasGupta,* D. M. Kroeger, C. C. Koch, and Y. T. Chou, "Flux Pinning by Grain Boundaries in Niobium Bicrystals Can Be Treated by the First-Order Perturbation of Ginzburg-Landau Free Energy."

J. M. Schultz,* J. S. Lin, R. W. Hendricks, J. Petermann, and R. M. Gohil, "Annealing of Polypropylene Films Crystallized from a Highly Extended Melt."

ASM Advisory Technical Awareness Council Committee Meeting, Cleveland, Ohio, March 25, 1980.

J. E. Cunningham,* "Trends in Analytical Electron Microscopy."

ANS Topical Meeting on Thermal Reactor Safety, Knoxville, Tennessee, April 8–11, 1980.

D. O. Hobson,* "A Review of Cladding-Coolant Interactions During LWR Accident Transients."

Joint Meeting of Student Chapters of the Society for Engineering Science and the Institute of Electrical and Electronic Engineers, University of Tennessee, Knoxville, Tennessee, April 9, 1980.

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

Sixth International Conference on Fluidized Bed Combustion, DOE, Atlanta, Georgia, April 9–11, 1980.

J. H. DeVan and T. G. Godfrey,* "Heat Exchanger Materials for Fluidized-Bed Coal Combustors."

Seminar, College of Engineering, University of Houston, Houston, Texas, April 10, 1980.

R. W. McClung,* "Current Activities in Nondestructive Testing at ORNL."

Invited talk, American Physical Society, Cornell University, New York, April 11–12, 1980.

C. J. Sparks, Jr.,* "Synchrotron Radiation Sources: Novel Optics and Changed Research Style."

Dynamic Compaction of Metal and Ceramic Powders Committee Meeting, Washington, D. C., April 14, 1980.

C. S. Yust* and L. A. Harris, "Electron Microscope Observations of Explosively Compacted Ceramics."

American Welding Society Annual Meeting, Los Angeles, California, April 14–18, 1980.

A. J. Moorhead,* M. B. Herskovitz, C. S. Morgan, J. J. Woodhouse, and R. W. Reed, "Fabrication of Sensors for High-Temperature Steam Instrumentation Systems."

D. A. Canonico,* "Materials Design and Fabrication of Large Pressure Vessels for Energy-Related Systems."

L. B. Spiegel and S. A. David,* "Microstructural Study of Laser Beam Welds in Single Phase Alloys."

D. P. Edmonds,* D. Yapp, and W. K. C. Jones, "Effects of Chemical Composition and Welding Conditions of 9 Cr-1 Mo Steel Welds."

R. L. Klueh* and J. F. King, "Elevated-Temperature Failure of Austenitic-Ferritic Dissimilar-Alloy Weld Joints."

D. A. Canonico* and W. J. Stelzman, "The Influence of Microstructure on the Fracture Toughness of Weld Metal."

R. J. Gray,* R. S. Crouse, and B. C. Leslie, "Basic and Unusual Techniques in Metallography Extend Our Understanding of Brazements."

Seminar, University of Tennessee, Knoxville, Tennessee, April 15, 1980.

M. L. Grossbeck,* "Fatigue of Irradiated Stainless Steel for Fusion Reactors."

Seminar at Max-Planck Institute, Stuttgart, FRG, April 21, 1980.

J. D. Holder,* "Synthesis of Oxide-Metal Eutectic Composites."

Seminar at Degussa Institute, Frankfurt, FRG, April 22, 1980.

J. D. Holder,* "Synthesis and Electronic Applications of Oxide-Metal Eutectic Composites."

*Speaker.

Seminar at Siemens Research Institute, Erlangen, FRG, April 23, 1980.

J. D. Holder,* "Synthesis and Electronic Applications of Oxide-Metal Eutectic Composites."

Seminar at Giesserei, FRG, April 25, 1980.

J. D. Holder,* "Synthesis and Electronic Applications of Oxide-Metal Eutectic Composites."

Seminar at Laboratory for Physical Chemistry, Eindhoven University, Netherlands, April 28, 1980.

J. D. Holder,* "Synthesis of Oxide-Metal Eutectic Composites."

Fourth International Conference on Plasma-Surface Interactions, Garmisch-Partenkirchen, FRG, April 21–25, 1980.

R. E. Clausing,* L. C. Emerson, and L. Heatherly, "Arcing Studies on ISX-B."

R. E. Clausing,* L. C. Emerson, and L. Heatherly, "Studies of Mechanisms of Hydrogen Recycle Using a Plasma-Wall Interaction Simulator."

American Ceramic Society, Chicago, Illinois, April 28–30, 1980.

C. S. Yust* and L. A. Harris, "TEM Analysis of Explosively Compacted Alumina."

P. S. Sklad,* R. W. Carpenter, N. J. Zaluzec, and J. E. Selle, "Phase Identification in Si_3N_4-MgO and Si_3N_4-Y_2O_3 Compacts by Convergent-Beam Diffraction and Energy Loss Spectroscopy."

A. Pasto,* "A Quantitative DTA Study of the U_3O_8-Al Thermite Reaction."

T. S. Lundy,* "The National Program for Building Thermal Envelope Systems and Insulating Materials."

D. P. Stinton,* J. S. Vavruska, P. Angelini, and W. J. Lackey, "Sintering Behavior and Characterization of Sol-Gel-Produced Synroc."

P. Angelini, D. P. Stinton, R. W. Carpenter, J. S. Vavruska, and W. J. Lackey,* "Phase Identification and Partitioning of Elements in Sol-Gel-Derived Synroc."

A. J. Caputo,* "Fabrication of Fuel Pins Using the Gel-Sphere-Pac Process."

T. N. Tiegs,* "Silver Release From SiC Coated Fuel Particles."

Seminar at Michigan Technological University, Houghton, Michigan, May 2–6, 1980.

C. L. White,* "Grain Boundary Segregation and Fracture in Noble Metal Alloys."

Technical Day Meeting of the Chicago Section of the American Society for Nondestructive Testing, Amoco Research Center, Naperville, Illinois, May 5, 1980.

W. E. Deeds,* "Looking Ahead Five Years in Eddy-Current Testing."

25th National Society for the Advancement of Materials and Process Engineering, San Diego, California, May 6–8, 1980.

J. L. Scott,* "The Development of Advanced Structural Materials for Fusion Power."

Electrochemical Society, St. Louis, Missouri, May 11–16, 1980.

R. E. Pawel* and J. J. Campbell, "Some Experiments and Calculations Regarding the Effect of Specimen Dimensions and Oxygen Solubility on Oxidation Kinetics."

Canadian Council of ASM, "Materials to Satisfy the Energy Demand," Harrison, British Columbia, May 11–16, 1980.

V. B. Baylor* and J. R. Keiser, "Corrosion and Stress Corrosion Cracking in Coal Liquefaction Processes."

Impromptu presentation at meeting of USA-INTOR Group, University of Wisconsin, May 13, 1980.

K. Farrell,* "Neutron Damage Response of Aluminum Alloys in INTOR."

Workshop on Alternate Nuclear Waste Forms and Interactions in Geologic Media, Glenstone Lodge, Gatlinburg, Tennessee, May 13–15, 1980.

P. Angelini,* D. P. Stinton, J. S. Vavruska, A. J. Caputo, and W. J. Lackey, "Sol-Gel Technology Applied to Alternative High-Level Waste Forms Development."

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*Speaker.

British Nuclear Energy Symposium, London, May 13–15, 1980.

M. J. Kania,* T. N. Tiegs, and K. H. Valentine, "Irradiated Performance Assessment of Coated Particle Fuels Using the IMGA System."

J M Robbins, M. J. Kania,* E. L. Long, Jr., "Gas Content Measurements of Irradiated Coated Particles Using the PGA System."

Westinghouse Research Laboratories, Pittsburgh, Pennsylvania, May 14–15, 1980.

A. F. Rowcliffe,* "The Application of Heavy-Ion Damage Studies to the Development of Materials for Fast Breeder Core Components."

ASTM Committee Week, Denver, Colorado, May 18–23, 1980.

D. A. Canonico,* "Relationship Among Cooling Rates, Microstructure, and Mechanical Properties of 2¼ Cr-1 Mo Steel."

First International Al-Li Conference, Stone Mountain, Georgia, May 19–21, 1980.

C. L. White,* "Grain Boundary Segregation and Intergranular Failure."

D. P. Edmonds* and G. M. Goodwin, "Cladding of 2¼ Cr-1 Mo Steel with Type 320Cb Stainless Steel."

American Society for Quality Control, 34th Annual Technical Conference, Atlanta, Georgia, May 20–22, 1980.

R. J. Beaver* and J. R. Weir, Jr., "A QA Management Approach Unique to R&D Programs."

International Cryogenics Materials Conference, Brookhaven National Laboratory, May 28–29, 1980.

D. S. Easton,* D. M. Kroeger, and C. C. Koch, "Superconducting and Mechanical Properties of Nb_3Sn Conductors Under Tensile Stress."

D. M. Kroeger,* D. S. Easton, C. C. Koch, and A. DasGupta, "Evidence for Microstructural Change Under Strain in Bronze-Process Nb_3Sn."

Annual Meeting of International Precious Metals Institute, Toronto, Canada, June 3, 1980.

C. T. Liu,* "Development of Iridium and Platinum Alloys for High-Temperature Applications."

Tenth International Symposium on Effects of Radiation in Materials (ASTM), Savannah, Georgia, June 3–5, 1980.

F. W. Wiffen,* J. A. Horak, D. P. Edmonds, and J. F. King, "The Influence of Irradiation on the Tensile Properties of Austenitic Stainless Steel Weldments."

K. Farrell,* "Microstructure and Tensile Properties of Heavily Irradiated 5052-0 Aluminum Alloy."

M. R. Hayns and L. K. Mansur,* "Applications of the Theory of Cavity to Dual Ion Swelling Experiments."

Second International Symposium on Ultrasonic Materials Characterization, National Bureau of Standards, Gaithersburg, Maryland, June 4–6, 1980.

S. Golan, L. Adler, K. V. Cook,* and D. Chwirut, "Ultrasonic Diffraction Technique for Characterization of Fatigue Cracks."

ACED Materials Science Conference, Argonne National Laboratory, June 5–6, 1980.

R. W. Swindeman,* "Damage Accumulation Mechanics in Pressure Boundary Materials Used for Coal Conversion."

American Nuclear Society, Las Vegas, Nevada, June 8–13, 1980.

G. W. Brassell,* "Boron Carbide Copper Cermet Fabrication for Neutron-Shielding Applications."

G. L. Copeland,* R. L. Heestand, and R. S. Mateer, "Melting Mixed Metal Scrap Reduces Volume and Contamination Level."

M. L. Grossbeck* and K. C. Liu, "Fatigue Behavior of Type 316 Stainless Steel Following Neutron Irradiation Inducing Helium."

T. N. Tiegs,* "Fission Product Pd-SiC Interaction in Irradiated Coated Particle Fuels."

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*Speaker.

National Synchrotron Light Source User's Meeting, Brookhaven National Laboratory, Upton, New York, June 9, 1980.

C. J. Sparks, Jr.,* "Oak Ridge Synchrotron Consortium of Radiation Experiments – X-Rays."

C. J. Sparks, Jr.,* "Some Things About X-Ray Optics for Synchrotron Radiation: August 1979 Report."

National Institute of Building Sciences, Washington, D.C., June 11, 1980.

T. S. Lundy,* "The National Program for Building Thermal Envelope Systems and Insulating Materials."

Symposium Commemorating the 50th Anniversary of Climax Molybdenum Company Research Laboratory, University of Michigan, Ann Arbor, June 17–18, 1980.

D. A. Canonico,* "Heavy Wall Pressure Vessels for Energy Systems."

BES Workshop on Nondestructive Evaluation, Los Alamos Scientific Laboratory, June 17–20, 1980.

R. W. McClung,* "A Review of NDE Problems in Fission Energy."

C. V. Dodd,* "Long-Range Research Needs for Eddy-Current Testing."

International Conference on Metallurgical Effects of High-Strain-Rate Deformation and Fabrication, Albuquerque, New Mexico, June 22–26, 1980.

C. S. Yust* and L. A. Harris, "Observation of Dislocations and Twins in Explosively Compacted Alumina."

International Conference on Dislocation Modeling of Physical Systems, Gainesville, Florida, June 22–27, 1980.

W. A. Coghlan* and M. H. Yoo, "Applications of Theoretical Point Defect-Dislocation Interactions to Physical Problems."

Seventh European Thermophysical Properties Conference, Antwerpen, Belgium, June 30–July 4, 1980.

J. P. Moore,* R. S. Graves, and R. K. Williams, "Thermal Transport Properties of Niobium and Some Niobium Base Alloys from 80 to 1600 K."

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*Speaker.

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