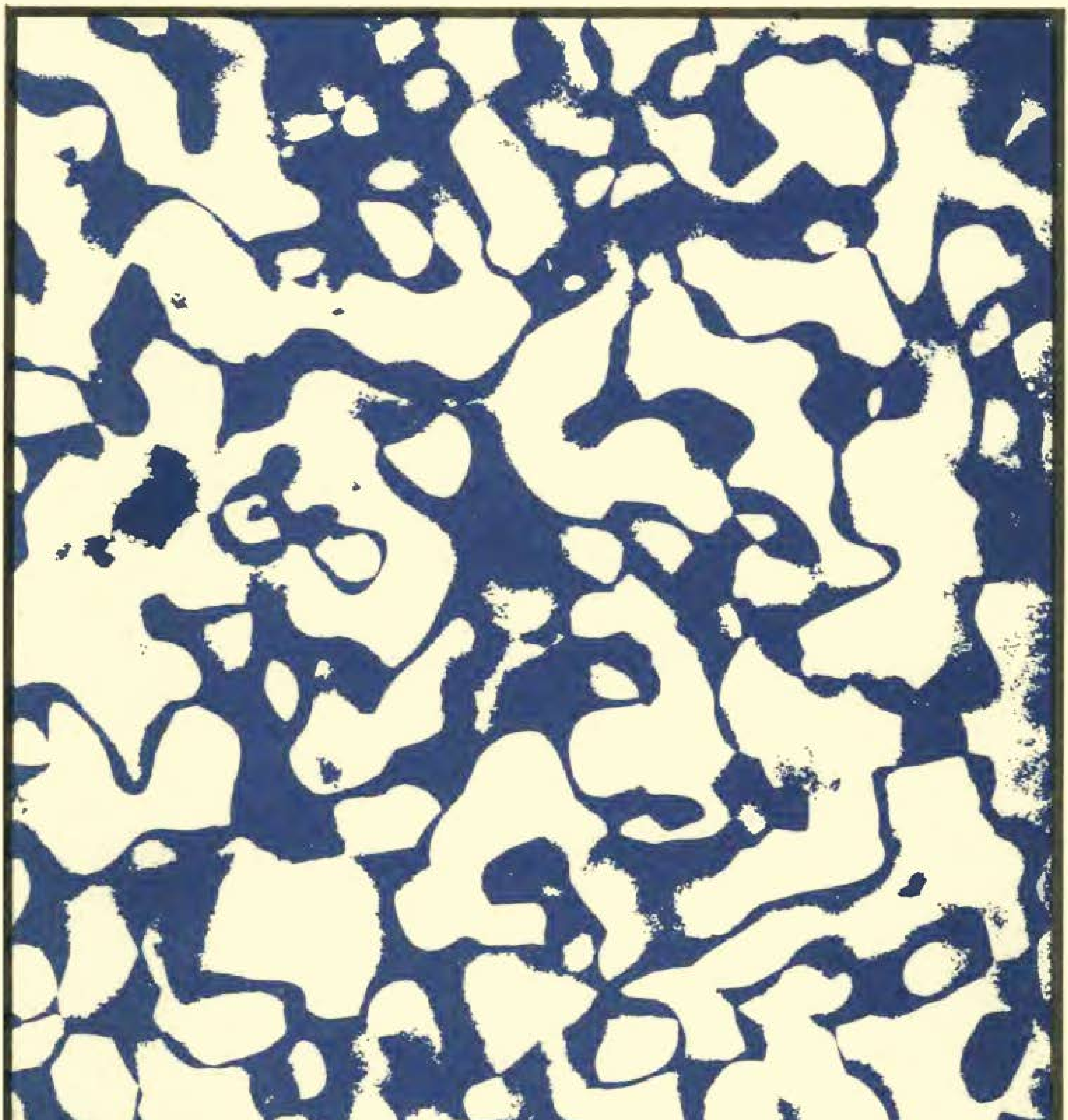
Winter 1979

Oak Ridge National Laboratory

review



THE COVER: Structural details of an ordered alloy of 23% vanadium, 22% iron, and 55% cobalt are revealed in this dark-field transmission electron micrograph at 195,000X magnification. The light areas are ordered domains while the darker, ribbon-like features are domain boundaries. Ductile ordered alloys are described in an article on page 10.

Editor
BARBARA LYON

Staff Writer
CAROLYN KRAUSE

Consulting Editor
ALEX ZUCKER

Art Director
BILL CLARK

Publication Staff: Technical Editing/LaRue Foster; Typography/Linda Jeffers; Makeup/Betty Jo Williams; ORNL Photography Department

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review

Volume 12 Number 1 Winter 1979

The Fall 1978 issue of the ORNL *Review* was erroneously designated Volume 11, Number 3, Summer 1978. It should have read Volume 11, Number 4, Fall 1978. We regret any inconvenience this may have caused.

DEPARTMENTS

OAK RIDGE NATIONAL LABORATORY

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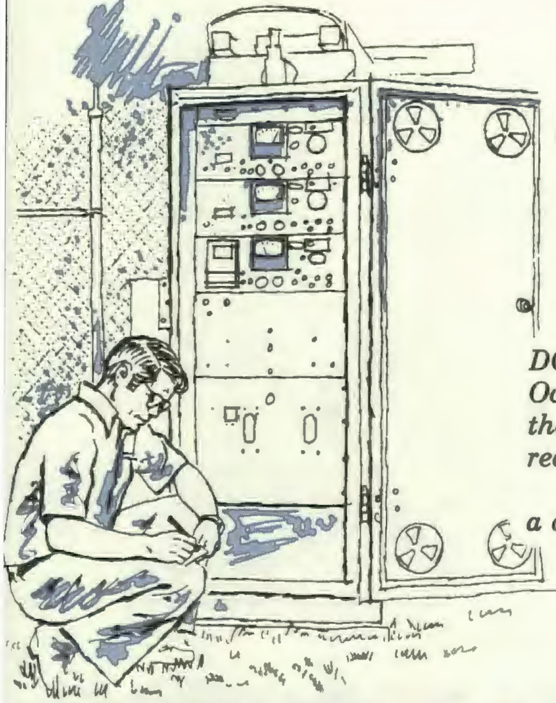

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.....rrrinnggg.....

"Environmental Coordinator's Office, Jo Brown speaking."

"Jo, may I speak with Tom Oakes, please?"

"One moment, please."

"Hello, Tom Oakes speaking."

"Tom, this is Jerry Wing [Head of Environmental Protection Branch, DOE-ORO]. DOE Headquarters has been informed by the National Oceanic and Atmospheric Administration that radioactive fallout from the above-ground test conducted by the People's Republic of China should reach the East Coast in about two days..."

"Thank you, Jerry. We will step up milk, water, and air sampling to a daily basis and keep you informed of the results."

ECO Watch

Environmental Protection at ORNL

BY TOM OAKES and KEN SHANK

The Chinese conducted four aboveground nuclear weapons tests between September 1976 and March 1978: on September 26, 1976; November 17, 1976; September 17, 1977; and March 15, 1978. Measurements of radioactivity in environmental samples during periods of fallout are made by contractors of the Environmental Protection Agency (EPA) and the Department of Energy (DOE); Oak Ridge National Laboratory (ORNL) is one of the DOE facilities that has a continuous monitoring program which can be augmented following such tests.

During periods of radioactive fallout, the Environmental Surveillance and Evaluation Section of the Industrial Safety and Applied Health Physics Division measures air concentrations of the important fission products over time; Jim Eldridge and others in the Analytical Chemistry Division assist in these endeavors. Weekly samples from a single station are analyzed via gamma spectrometry to detect changes. During 1976, it was observed that beryllium-7, a radionuclide produced by cosmic-ray interactions, was relatively constant for the entire period, but a decrease in levels of radionuclides from fallout on air filters was consistent with periods of rainfall in late October 1976, indicating a washout of the radioactivity. At the beginning of 1977, a slow increase in levels occurred because of another pass by the cloud from the second detonation.

One of the most important pathways of radiation exposure occurring due to fallout from atmospheric weapons testing is the transfer of radioiodine through milk. Following the September 17, 1977, test, daily milk sampling was conducted by ORNL over a three-week period, and a rapid rise and fall in radioiodine levels was found. The maximum level found locally was 150 pCi/liter on September 30, 1977. (This compares with the maximum nationally reported value of approximately 1000 pCi/liter.) The peak value of iodine-131 in milk occurred three days later than the peak levels of 90 pCi/liter of iodine-131 and 130 pCi/liter of barium-140–lanthanum-140 in rainwater; and 3×10^{-7} pCi/cc of neptunium-239, 5.7×10^{-8} pCi/cc of iodine-131, and 2.1×10^{-10} pCi/cc of barium-140–lanthanum-140 on air filters.

A time analysis was made for 1977 for the three air-monitoring networks at ORNL for gross beta concentrations in rainwater. The highest peak, around October 15, was a result of the September 1977 detonation. Other peaks which corresponded to the passing of the radioactive cloud from tests of the previous year were also observed.

In East Tennessee, the highest iodine-131 levels are found in milk, and the dose commitment for the highest iodine-131 concentration of 150 pCi/liter was determined to be 5×10^{-4} mrem to the whole body and 0.3 mrem to the thyroid of an adult for ingestion of 1 liter of milk. Maximum permissible radiation dose commitments per person per year have been established at 500 mrem. These radionuclide concentration values are given to DOE-ORO on a short turnaround basis during fallout periods, and they are relayed to EPA in Washington by DOE under an interagency agreement. The Chinese fallout measurements, however, are only one aspect of ORNL's wide-ranging environmental-monitoring activities.

Environmental Evaluation

The Environmental Surveillance and Evaluation Section (ESES), in conjunction with the Environmental Coodinator's Office (ECO), monitors for both radioactivity and other pollutants in the atmosphere, water, foodstuffs, biological specimens, terrestrial environment, and other media of interest. These activities demonstrate ORNL's compliance with federal and state environmental regulations.

For atmospheric assessment, ESES maintains three monitoring networks. The first is the local air-monitoring network, an array of 23 stations relatively close to ORNL operational activities. Next is the perimeter air-monitoring network, made up of nine stations surrounding the DOE-controlled area. These stations provide data for evaluating the impact of all UCC-ND operations in Oak Ridge on the immediate environment. Finally, there is the remote air-monitoring network that contains eight stations located outside the DOE-controlled area at distances of 12 to 75 miles from ORNL. Samples from these stations are collected by TVA staff and mailed to ORNL for analysis and evaluation; each station is serviced by the ESES staff monthly. These different monitoring networks provide for the collection of (1) airborne pollutants by air-filtration techniques, (2) particulate fallout material on gummed-paper trays, (3) waterborne contaminants in rainwater, (4) radioiodine using charcoal cartridges, and (5) external gamma radiation via thermoluminescent dosimeters.

The Laboratory has various stations in which surface water is sampled for radioactive and nonradioactive pollutants. Low-level radioactive effluents origi-

On October 13, 1978, Presidential Executive Order 12088, "Federal Compliance with Pollution Control Standards," was signed by President Jimmy Carter. This order was issued to ensure federal compliance with, among other laws, the Toxic Substances Control Act; the Federal Water Pollution Control Act; the Safe Drinking Water Act; the Clean Air Act; the Federal Insecticide, Fungicide and Rodenticide Act; the Solid Waste Disposal Act, and also all the amendments to these acts. This order was not unexpected because federal compliance for most of these acts was already required.

In order to meet the requirements of the fast-proliferating environmental protection laws, the Laboratory has established the Environmental Coordinator's Office. This office has an overseeing function and works with all divisions at ORNL. The environmental monitoring functions of the office are performed by the Environmental Surveillance and Evaluation Section of the Industrial Safety and Applied Health Physics Division. Tom Oakes and Ken Shank hold dual capacities in the office and section. Tom, who has an M.S. from Virginia Polytechnic Institute and is currently pursuing work on a Ph.D. in environmental engineering, is the ORNL environmental coordinator and head of the section. Ken, who has a Ph.D. in bionucleonics from Purdue, is a senior staff member in the office and group leader in the section. Shown here (Tom seated) with their secretary, Jo Brown, they cope with the increasing demands for environmental assessment and control that are required as the Laboratory hustles to comply with new environmental legislation.

nating from ORNL operations are discharged after treatment to White Oak Creek, a small tributary of the Clinch River. The radioactive and nonradioactive content of the creek discharge is sampled at White Oak Dam, the last control point along the stream prior to the entry of the creek into the Clinch River. Additional sampling of the effluents is performed by the Operations Division of ORNL.

The section also operates water-sampling stations at other locations downstream from the ORNL discharge point. These stations are at the intersection of White Oak Creek and the Clinch River, at the Oak Ridge Gaseous Diffusion Plant water intake, and at Center's Ferry near Kingston. A station is also maintained upstream in the Clinch River at Melton Hill Dam to provide background information. A variety of analyses are performed on the water samples at weekly, monthly, and quarterly intervals.

Milk is the principal foodstuff analyzed and is collected from local farms and a dairy. Samples are taken every week from eight local stations, and monthly from seven stations located at distances up to 50 miles away. This frequency is increased during periods of fallout. The samples are analyzed routinely for strontium-90 and iodine-131.

Various species of fish and other aquatic life (such as turtles) are also collected and analyzed routinely for radioactivity and occasionally for nonnuclear contaminants. Fish in the Clinch River near the inflow of White Oak Creek are analyzed quarterly, and those from other locations in the Clinch River are analyzed annually. Tissue from road-killed animals is also analyzed for radioactivity. In 1977, eight deer carcasses were analyzed with the ORNL whole-body counter.

Soil and grass samples are collected annually from locations near the perimeter and from remote stations. The samples are analyzed for baseline information on uranium, plutonium, and gamma emitters.

The ESES also conducts a number of important special projects. The section analyzes foodstuffs for certain radioactive and stable elements. Since this project started in the summer of 1976, approximately 50 foods, purchased from local commercial supermarkets, have been analyzed for gamma emitters and for 40 stable elements. This permits a comparison of levels in vegetation grown in the Oak Ridge area with those of produce obtained from the supermarket. Thus far, no significant difference has been detected between the commercial and homegrown foodstuffs.

Another special project of the section since the fall of 1977 is the placement of approximately 100 thermoluminescent dosimeters (TLDs) in residences in the Oak Ridge–Knoxville area. The TLDs, which are changed every three months, allow for the determination of the range and fluctuations that exist in the natural background radiation levels to which local residents are exposed. Fluctuations up to a factor of 2 in the same resi-

The NPDES permits apply to the ORNL sewage-treatment plant. Here (from left) Ken Shank, Ed Beauchamp, Gerry Dixon, and Tom Oakes discuss the new rulings.

dence have been found when the dosimeter readings are compared for various time periods. In addition, correlations between the radiation levels, the type of house, and the ventilation characteristics of a particular residence will be made in later research studies. These radiation doses can then be assessed in comparison to any possible exposure from the Oak Ridge facilities.

The ESES staff has also recently conducted an assessment of biological monitoring programs at nuclear facilities. One major conclusion reached in this analysis is the need for DOE and other nuclear sites to strive toward preparing and reporting radioactive concentrations in biological specimens in a similar manner in order to facilitate interlaboratory comparison. The lack of standards for radioactive concentrations in fish was also noted as a current deficiency.

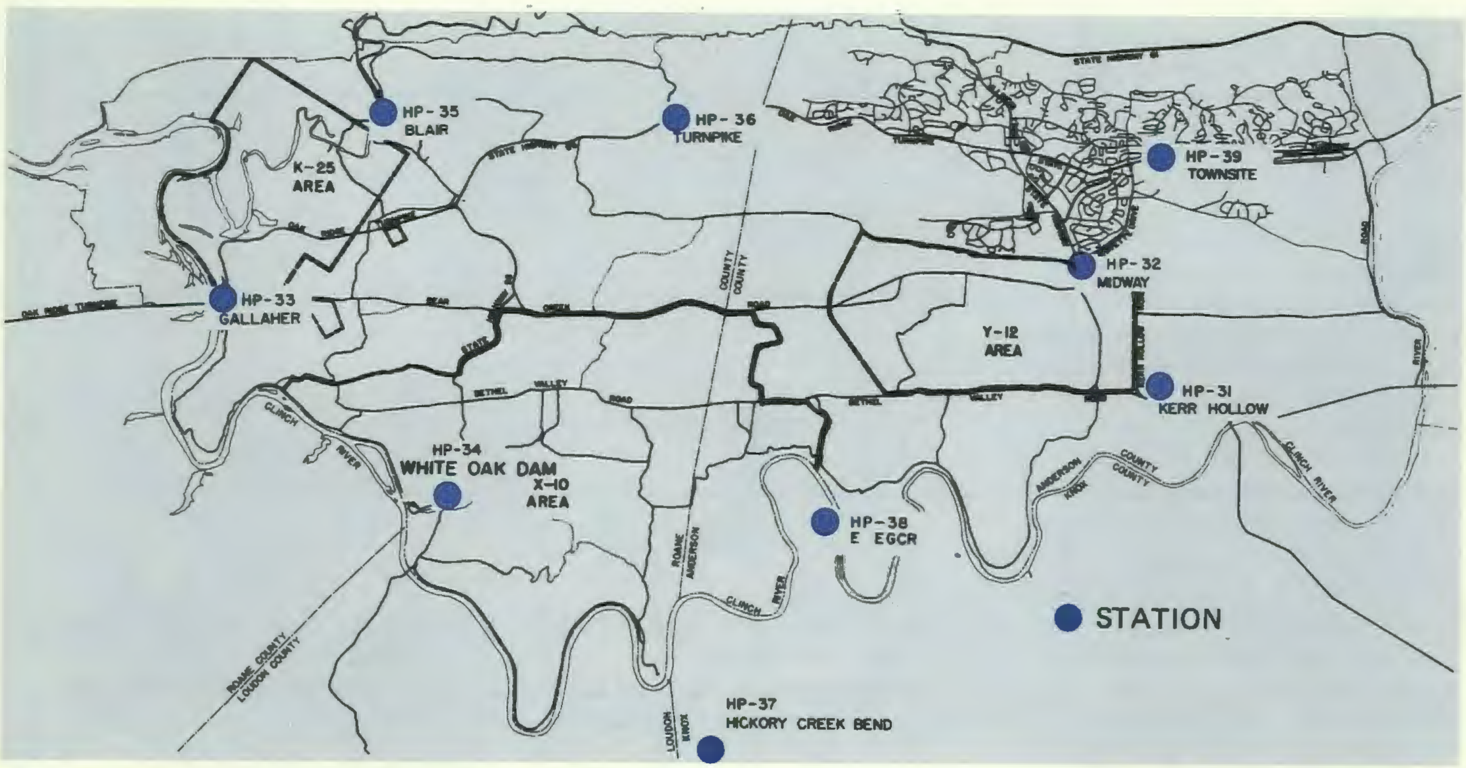
Finally, the ESES sometimes plays the role of detective by tracing abnormal occurrences in environmental samples to some operational process. Several years ago, for instance, an abnormally high radiation reading was observed for uranium content in one of the perimeter air monitors located close to K-25. When the operational people at K-25 were informed of this anomaly, they checked their processes and found that one of the cascades had a small leak. (This incident is described in *Environmental Monitoring Report, U.S. ERDA-ORO, Calendar Year 1976,* Y/UB-6, May 1, 1977.)

The section has devoted considerable attention to quality assurance. The QA program in ESES was initiated to ensure a high degree of accuracy and reliability of the section's programs. A computer program is used to check sample flow and comparison studies involving radioactivity within the Nuclear Division and DOE system. A private firm checks the nonnuclear data, such as pH and biological and chemical oxygen demand. The other main component of the QA program consists of written descriptions of all activities pertaining to the section and adherence to the procedures, which includes (1) operating procedures for each activity; (2) inspection lists of operating maintenance activities; (3) check-off frequency lists for all quality-assurance steps, such as schedules for equipment inspection and test control; and (4) identification of the role, responsibilities, and authority of each staff member as related to QA.

Environmental Coordination

The environmental coordinator, Tom Oakes, has the major responsibility for environmental protection at the Laboratory. To fulfill these responsibilities, he

- coordinates the Laboratory's pollution abatement and monitoring programs and serves as liaison among the various ORNL groups involved in pollution control, ORNL management, and the UCC-ND Office of Safety and Environmental Protection;
- identifies areas where development work, additional monitoring equipment, and changes in waste-disposal practices are required for pollution abatement;
- maintains adequate records on significant effluents within the installation;
- reviews, or provides for review of, the design, acquisition, and installation of required pollution control equipment;
- assists in preparing environmental impact statements when required for Laboratory construction projects;
- prepares periodic reports on radioactive and nonradioactive effluents as required by UCC-ND management and DOE; and
- reviews all Laboratory construction projects for environmental impact.



A map of the DOE-controlled area showing the locations of perimeter air-monitoring stations.

Each ORNL division has the responsibility for identifying all of its potentially significant pollution sources and informing the ECO. The coordinator must also be knowledgeable concerning all environmental laws and regulations as they apply to the Laboratory.

Environmental Laws

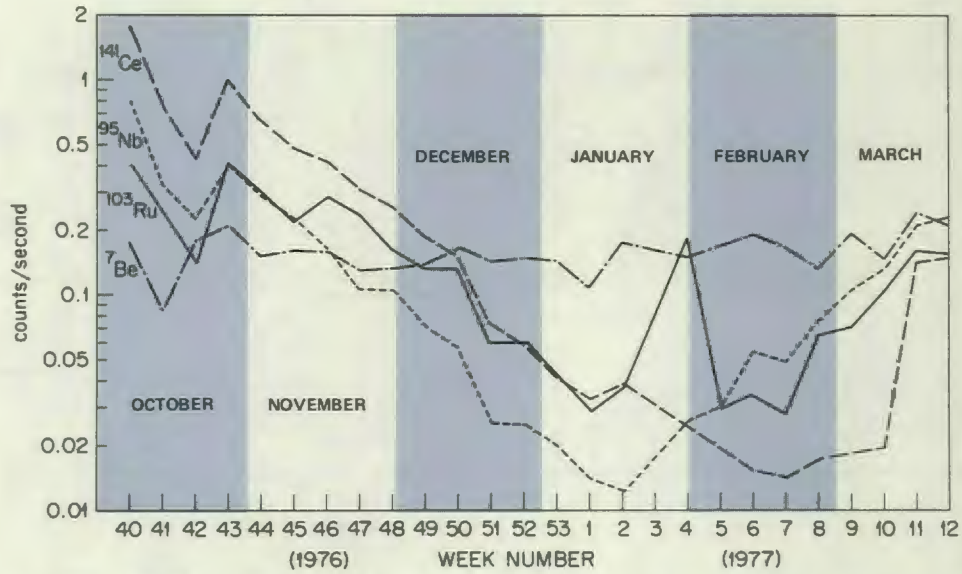
Recently enacted federal and state environmental laws (e.g., Water Pollution, Air Pollution, Pesticide, Resource Conservation and Recovery, and Toxic Substances Control acts) are having a significant impact on ORNL operations.

The National Environmental Policy Act of 1969, commonly referred to as NEPA, was signed into law on January 1, 1970, and has dramatically affected the decisions made by the federal agencies. The national environmental policy declared in NEPA is the first ever enacted by the Congress. It constitutes a general commitment of the federal government to "use all practicable means" to conduct federal activities in a way that will promote "the general welfare and harmony" with the environment.

The practical importance of NEPA today stems principally from its procedural requirements, including that of an environmental impact statement (EIS) for all major federal activities. The act mandates detailed consideration of alternative facility designs and a comprehensive cost-benefit balancing of economic and environmental factors. Each major construction project at ORNL requires an environmental assessment to determine whether or not an environmental impact statement is required. These assessments and impact statements are put together by the staff of the ECO and the Energy, Environmental Sciences, and Engineering divisions.

The Water Pollution Control Act mandated the establishment of effluent-limitation guidelines for point-source categories based on the application of best practicable technology for pollution control by July 1, 1977, and the best available technology by July 1, 1984. The provisions of this act illustrate the complexity characteristic of all the environmental laws. This act established the National Pollutant Discharge Elimination System program which regulates discharges into navigable waters. Under the NPDES program, the EPA Administrator may, after opportunity for public hearing, issue a permit for the discharge of any pollutant or combination of pollutants upon condition that such discharges will meet applicable requirements. ORNL has an

Variation in fallout concentrations in four nuclides at the perimeter air monitor at the intersection of Kerr Hollow and Bethel Valley roads during the fourth quarter of 1976 and the first quarter of 1977.



NPDES permit covering four discharge points: White Oak Creek, Melton Branch, the Main Sanitary Treatment Facility, and the 7900 Area Sanitary Treatment Facility.

There are specific requirements imposed at each discharge point; for example, White Oak Creek must maintain a pH of 6 to 9 and a dissolved-oxygen content greater than 5 ml/liter. These parameters are continuously monitored at the discharge point, with the data telemetered to Building 3015, where a central monitoring station is maintained around the clock. This central facility also monitors radioactive discharges throughout the Laboratory.

The discharge points are also sampled periodically as established by the permit. For example, White Oak Creek and Melton Branch are sampled each week for chromium. Our permit requires that the chromium discharge be no greater than 0.05 mg/liter. In order to meet this requirement, it was necessary to discontinue the use of chromium as an anticorrosive agent in all of our cooling towers. Almost the full two years allowed in the permit passed before a suitable substitute was found with the proper characteristics for use in the High Flux Isotope Reactor and Oak Ridge Research Reactor cooling towers.

At present there is only one parameter that is difficult to keep below the permit level, and one that is particularly difficult during cool weather: This requirement stipulates that ammonia-nitrogen must be kept below a maximum concentration of 5 mg/liter in the effluent of the Main Sanitary Treatment Facility. Because this requirement was not in force at the time of the original design of the facility, it was not given any consideration. (The solution to this problem is addressed in the section entitled "Line Items.")

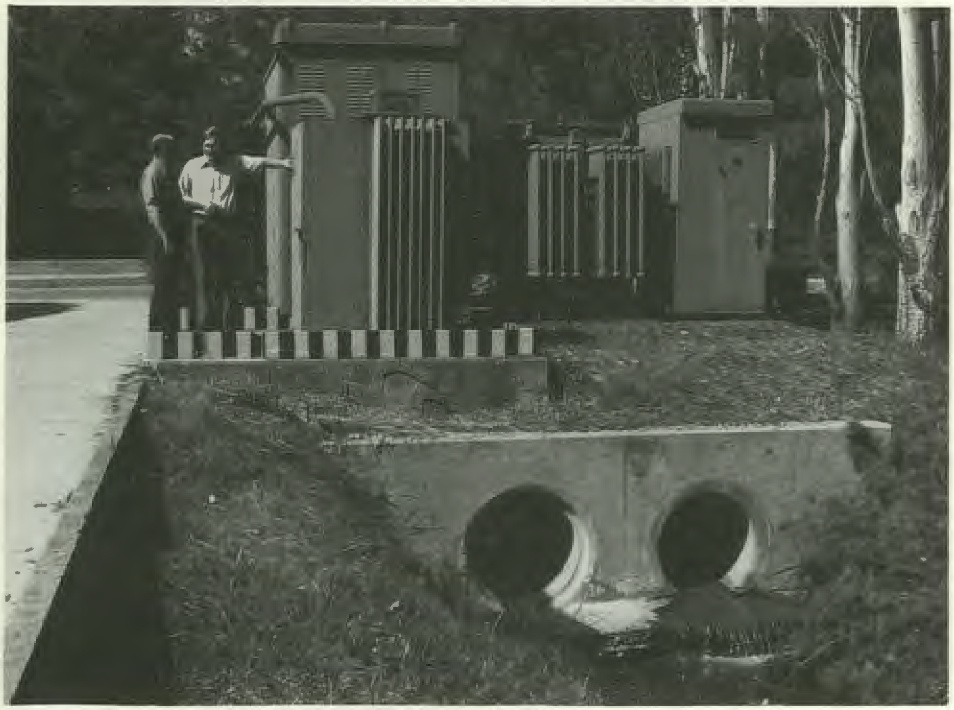
Another aspect of the Water Pollution Control Act requires protection against and reporting of oil spills. Many questions regarding oil spills are covered by this law. Most are addressed in the EPA publication *Oil Pollution Control* (1974), which answers a number of questions in relation to the ORNL site:

- *What is a spill?*
  A spill is a discharge of oil, which causes a visible sheen, into waters.

- *What waters?*
  All inland, navigable waters of the United States and waters from flood plains and wet lands. At ORNL, such areas as White Oak Creek, Melton Branch, White Oak Lake, and all holdup ponds, qualify under this definition. Discharges into any drains must be reported.

- *Who is involved?*
  The law provides a $10,000 fine or a year in jail, or both, for the "person in charge of a vessel or facility" spilling oil who fails to immediately notify the commander of the nearest U.S. Coast Guard unit or the regional office of the EPA. At ORNL, all spills must be reported to the Environmental Coordinator's Office within the first eight hours of the spill. This information is first reported to ORNL management and then to DOE-ORO within 24 hours after the spill is discovered. Quick reporting allows immediate steps to be taken to contain the spill as near the source as possible.

- *Can suits other than from the U.S. Government result from spills?*
  Yes. Citizens, states, and private groups can sue for damages.



All ORNL transformers carry stickers warning of their content of PCBs, and here Ken Shank points one out to Ed Beauchamp. The sticker warns of the necessity of reporting any spill, however small, to the Environmental Coordinator's Office.

Reporting and proper treatment of spills are important, because the Supreme Court has ruled that "guilty intent" is not necessary for criminal convictions, meaning that environmental negligence can be penalized by imprisonment, and conscious wrongdoing is not necessary for convictions. If a spill is discovered, ORNL employees are advised to take the following immediate action:

1. Stop the spill at the source.
2. Close all valves and drains.
3. Block storm sewer and drainage ditches.
4. Do anything that can be done to prevent the spill from reaching a waterway.
5. After taking action, report the spill without delay to the ECO (574-6669).

Spill prevention control and countermeasure plans for hazardous materials are being developed for the Laboratory by the Environmental Coordinator's Office. Such actions as diking of transformers that contain oil or polychlorinated biphenyls (PCBs) are an important part of these plans. The Laboratory has many transformers containing large quantities of PCBs. Many EPA regulations dealing with PCBs are now being implemented. Proper procedures for marking, storing, transporting, and disposal of PCB containers at ORNL are being developed. The actual operation of this will be performed by members of the Plant and Equipment Division, under the direction of Mike Shearin.

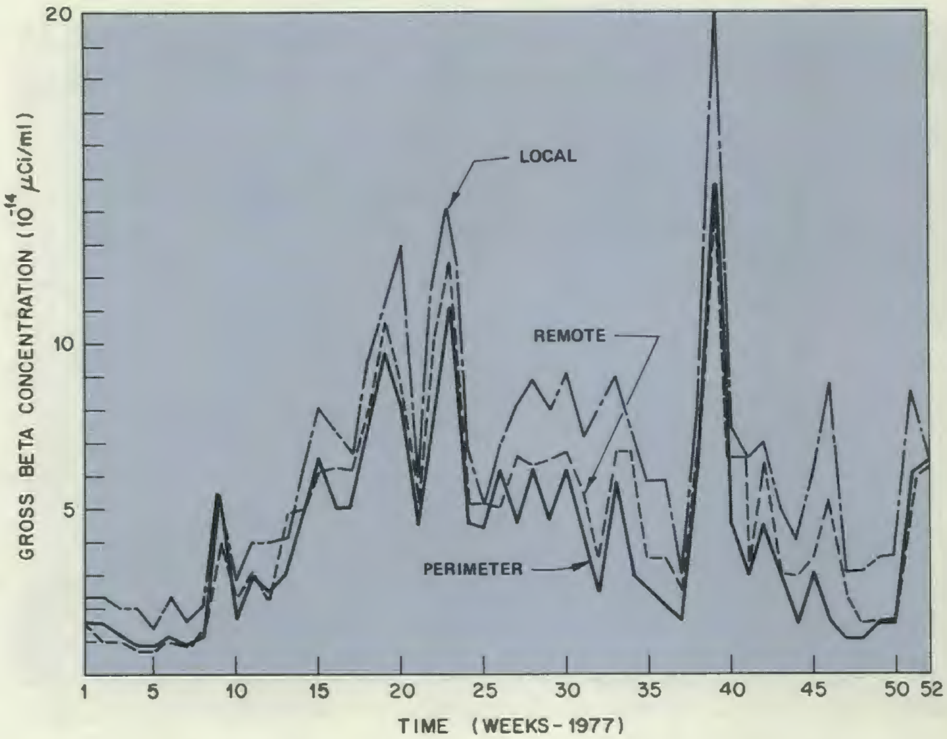
The Safe Drinking Water Act of 1974 was an amendment to the Public Health Service Act. The SDWA authorized EPA to establish federal drinking water standards for protection from all harmful contaminants, applicable to all public water supplies in the United States, and established a joint federal-state system of compliance with standards and protection of underground sources of drinking water. Some of the standards established in this act are being proposed for use in determining hazardous wastes under the Resource Conservation and Recovery Act.

The 1970 Clean Air Act Amendments to the Air Pollution Control Act first enacted in 1955, provided for the establishment of national ambient-air-quality standards. This act was again amended in August 1977. These amendments will have a large impact on federal facilities because the amendments constitute a major change from the previous stipulation that federal facilities comply only with substantive requirements, such as emission limitations. What the 1977 amendments require is that air-effluent release points (hoods, stacks, etc.) have their own air permit; ORNL has over 1000 air-effluent release points.

The 1972 Environmental Pesticide Control Act gave EPA authority to regulate usage of pesticides and strengthened enforcement procedures. DOE has strict controls on the Laboratory's insecticide, fungicide, herbicide, and rodenticide programs. The ORNL pesticide program is run by the Plant and Equipment Division and is reviewed by the ECO.

The Resource Conservation and Recovery Act of 1976 takes a multifaceted approach toward solving the problems associated with the growing ton-

Gross beta concentrations in rainwater recorded on the ORNL air-monitoring network over 1977. Chinese bomb test occurred on September 17.



nage of discarded materials generated each year. In supplanting the existing Solid Waste Disposal Act of 1965, RCRA greatly expands the role of the federal government in the field of solid-waste disposal. In particular, it provides for technical and financial assistance to state and local governments and to interstate agencies for the development of solid-waste management plans; provides for training grants; and stringently regulates waste handling and disposal. In addition, RCRA promotes a research and development program toward demonstration, construction, and application of solid-waste management and establishes a cooperative effort among the federal, state, and local governments, and with private enterprise. The major regulatory program of RCRA deals with regulating the treatment, storage, transportation, and disposal of hazardous wastes; it is this aspect that will have the greatest impact on ORNL in the future.

The Toxic Substances Control Act of 1976 provides the EPA with authority to require testing of chemical substances, both old and new, which enter commerce and to regulate them where necessary. Although this authority supplements parts of existing legislation, such as the Clean Air and Water acts and Occupational Safety and Health Act, its significance lies in the fact that, prior to 1976, there was no general federal requirement that the thousands of new chemicals developed each year be tested for their potential environmental or health effects before being introduced into commerce.

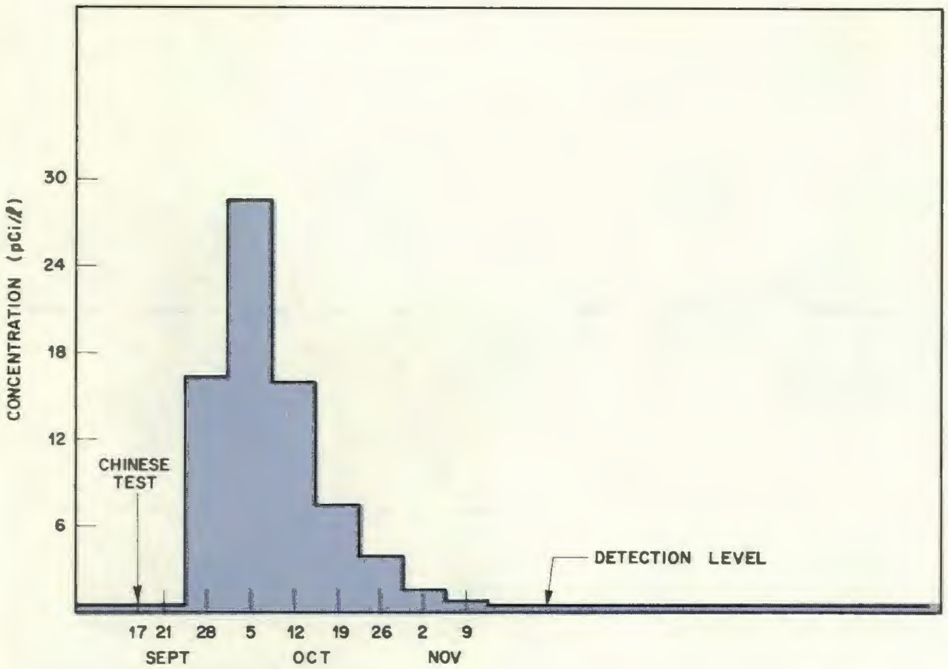
Recent experience illustrates the hazard of this omission. One example is the widespread contamination by organic mercury. Even though by 1972 the FWPCA controlled direct emissions of mercury to the environment, there was no federal authority to require multiple testing of the effects of various mercuric compounds or to regulate the many uses of mercury in industry, commerce, and consumer products. Another episode in the early 1970s involved PCBs used in such diverse applications as printing inks and hydraulic fluid.

The new law has two main regulatory goals: (1) to acquire sufficient information to identify and evaluate potential hazards from chemical substances; and (2) to regulate the production, use, distribution, and disposal of such substances where necessary. In particular, Section 8(e) of the act requires notification of substantial risk. What this means is that if a researcher at ORNL is working with or testing a chemical or a mixture of chemicals and finds the substance to be toxic and a risk to health, these findings should be reported to EPA. The ECO is currently working on notification procedures for the Laboratory.

Line Items

In addition to the major responsibilities of the ESES and the ECO as listed, there are other ongoing functions that should be mentioned. Three line items in particular are being pursued by these groups. (The term "line item" is being used here to mean a capital expenditure large enough to require approval by Congress.)

The first line item deals with assuring compliance with the objectives established in the 1972 Water Pollution Act, as amended by Clean Water Act



Iodine-131 concentrations in milk following the Chinese bomb test of September 17, 1977, taken from an average at eight local farms.

of 1977, for "best available treatment economically achievable," designated BATEA. The parameters of primary concern at ORNL are pH, ammonia, and sewage control. Original plans call for the neutralization of coal-yard runoff, ammonia stripping of the effluent from the sewage-treatment plant, expansion of the 7600 Area drainage field, and installation of a package treatment-plant facility for the HFIR Area.

The facilities for neutralization of coal-yard runoff will be located near the inlet to the existing settling pond at ORNL and will consist of caustic storage, a mix tank and associated instrumentation for automatic control of pH between 6 and 9, and monitoring equipment for the pond effluent. These neutralization facilities are required to ensure compliance with the pH restrictions.

The ammonia-stopping facility at the sewage-treatment plant, which is also needed to ensure pH compliance, will consist of lime-feed equipment, a reaction-and-surge tank, a stripping tower, and sludge-dewatering and ancillary equipment. This system is designed to maintain the sewage-treatment-plant effluent at an ammonia concentration below 5 mg/liter. A small structure will house the lime-feed and sludge-dewatering equipment.

The second item is listed as "Environmental and Effluent Monitoring Systems Upgrade." The purpose of this project is to modernize existing liquid and gaseous environmental-monitoring stations at ORNL, to add stations to provide more detailed coverage of the surrounding area, and to provide a new data-handling facility.

The third item is called "Upgrading Streamflow Monitoring Stations." The purpose of this project is to improve and to expand the three principal stream-flow monitoring stations within the White Oak Creek drainage basin; these include the stations at White Oak Creek, Melton Branch, and White Oak Dam. Work will include the design and construction of weirs, flumes, or similar facilities with the capability to measure both normal and storm flows.

Conclusions

There are other items of interest currently under analysis in the ECO. One is the disposal of oil and hazardous chemicals at the Laboratory. Old methods of disposal of these substances are no longer suitable; therefore, the decision to dispose of them on the site or to ship them off the site is a problem of major concern at the present time.

One other project is the ORNL Environmental Impact Study. The ESES and the ECO will participate in a lead role over the next year, during which time environmental samples will be collected. This activity is being carried out in cooperation with the Environmental Sciences and Energy divisions.

Finally, the goal of the ORNL ECO is to protect the environment and to obey the laws with the least impact on the excellent research programs at the Laboratory. To ensure that the ESES and ECO actions are compatible with the goals of ORNL, UCC-ND, and DOE, staff members from other divisions (e.g., Environmental Sciences, Energy, Engineering, Health, and Operations) and from the Environmental Policy Office, as well as management personnel, are frequently brought in for decision making. In addition, the assistance and understanding of all Laboratory staff members are required. This, we have found, is the best policy when working in the increasingly complex world of environmental protection.

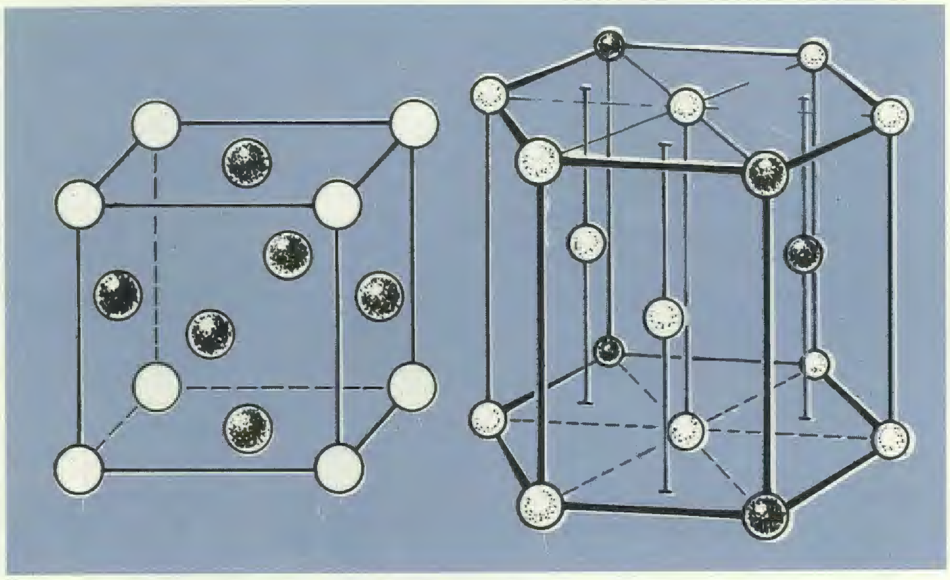
Chain Liu and Hank Inouye have been in the alloy development business together since 1967 when Liu joined ORNL's Metals and Ceramics Division. A native of Nanking in mainland China, Liu completed his undergraduate studies at National Taiwan University and served as an instructor in mechanical engineering at the Chinese Naval Academy prior to his arrival in the United States in 1962. Five years later, he earned a Ph.D. in materials science from Brown University. Inouye has been an ORNL staff metallurgist since 1952. He was born in Oak Creek, Colorado, and served with the U.S. Army in Italy during World War II. He worked for the National Bureau of Standards and American Brake Shoe Company, and earned a master's degree in metallurgy from the Massachusetts Institute of Technology before coming to Oak Ridge. Liu and Inouye teamed up to develop new alloys of platinum-rhodium-tungsten, iridium-hafnium, and iridium-tungsten for which they have received patents. They also helped test refractory alloys and developed improved iridium alloys used in the space program. For this work, they have been honored by NASA and ERDA. They are now developing and testing ductile long-range-ordered alloys that stay strong in high-temperature environments. Here Inouye, left, and Liu compare samples of ordered alloys.

Ductile Ordered Alloys

Materials for Advanced Energy Systems?

By CAROLYN KRAUSE

In an era of concern about dwindling energy sources, it it is important that ways be found to extract and use maximum amounts of energy from the fuels we have left. One way is to improve our efficiency in generating electricity by operating reliable power systems at the highest possible temperatures. Because standard alloys and commercial superalloys



Alloys having the cubic-ordered structure (left) are more ductile than those possessing the hexagonal-ordered structure. Each "ball" represents an atom.

used for structural materials tend to lose strength with increasing temperature, limitations are necessarily imposed on operating temperatures of conventional power plants and advanced energy systems under development. How to take a giant step forward in energy conservation is a problem that has fallen into the laps of the materials scientists. In an attempt to solve this problem, Oak Ridge National Laboratory metallurgists have developed and have started testing a new class of alloys that may overcome many of the materials limitations of advanced power systems, such as fast breeder reactors, high-temperature gas-cooled reactors, space electric power systems, and fusion devices.

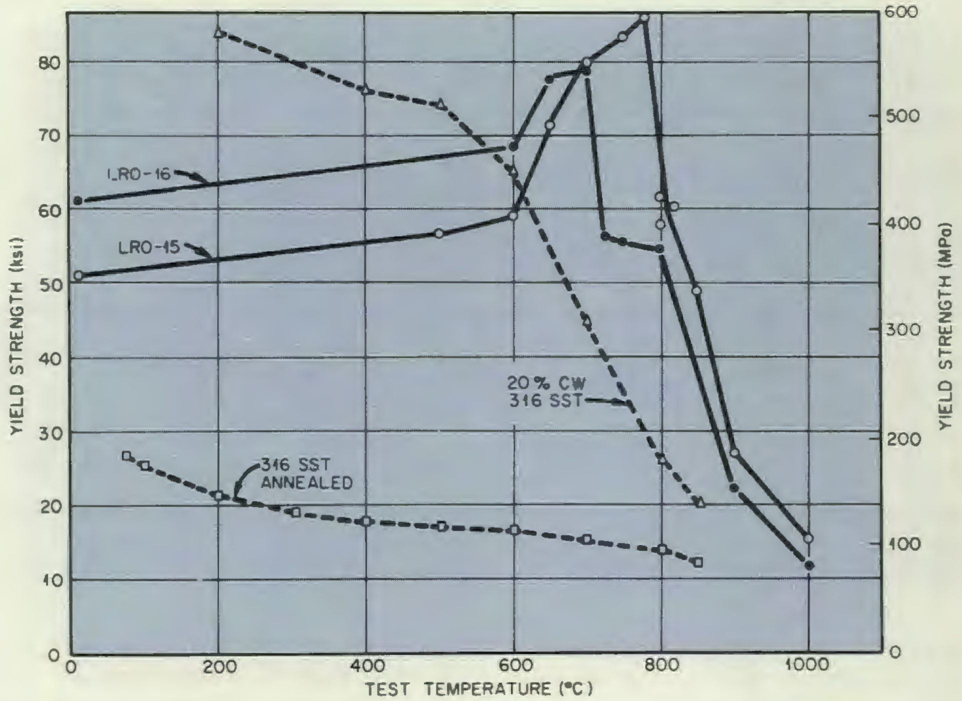
Ten years ago, Chain T. Liu of ORNL's Metals and Ceramics Division began investigating alloys exhibiting long-range order because they maintain superior strength and stability at high temperatures. Liu was interested in these ordered alloys (or LRO alloys) for possible application in the space program due to their potential for withstanding degradation from long-term service at high temperatures in a space vacuum. Liu and Hank Inouye had been working on developing alloys for cladding hot isotopes used as energy sources aboard earth satellites and space probes.

In his research, Liu had learned about these materials' unusual resistance to deformation that makes the alloys exceptionally strong and hard even at elevated temperatures. "Long-range order" means that the atoms arrange themselves in a definite pattern that repeats itself; such an ordered lattice can extend for a distance of more than 100 atoms. By contrast, the different atoms in standard alloys are mixed somewhat randomly, and this randomness increases with rising temperatures. Unlike ordered alloys, standard alloys have weak atomic bonds, which cause the alloys to lose strength at high temperatures.

Liu knew from previous studies that ordered alloys were beset with a severe problem: they are brittle in ordered states. They could not be fabricated by ordinary means, nor could they be expected to resist shock loading in high-temperature structural applications. In the metallurgist's terminology, these alloys have poor ductility—they cannot be pulled or stretched very far before breaking. They are too much like peanut brittle and not enough like taffy. Brittleness is unacceptable in a cladding that contains a radioactive isotope such as the oxide of plutonium-238; the material in a vehicle hurtling from outer space could not survive reentry impact at the earth's surface.

Search for a Ductile Alloy

Liu pursued his search for an ordered alloy that might be more ductile than its cousins. After all, there was the possibility that there existed LRO alloys whose mechanical properties such as ductility had not yet been studied. Long-range order for alloys, first predicted in 1919 by G. Tammann of Göttingen, Germany, and verified experimentally in 1923 by E. C. Bain of the United States in his investigations of copper-gold (Cu_3Au) crystals, had long been of interest to researchers trying to determine the relationship between atomic order and mechanical properties. The de-



As the temperature increases, the yield strength of type 316 stainless steel declines. But the yield strength of LRO alloys containing iron increases with temperature up to the critical ordering temperature.

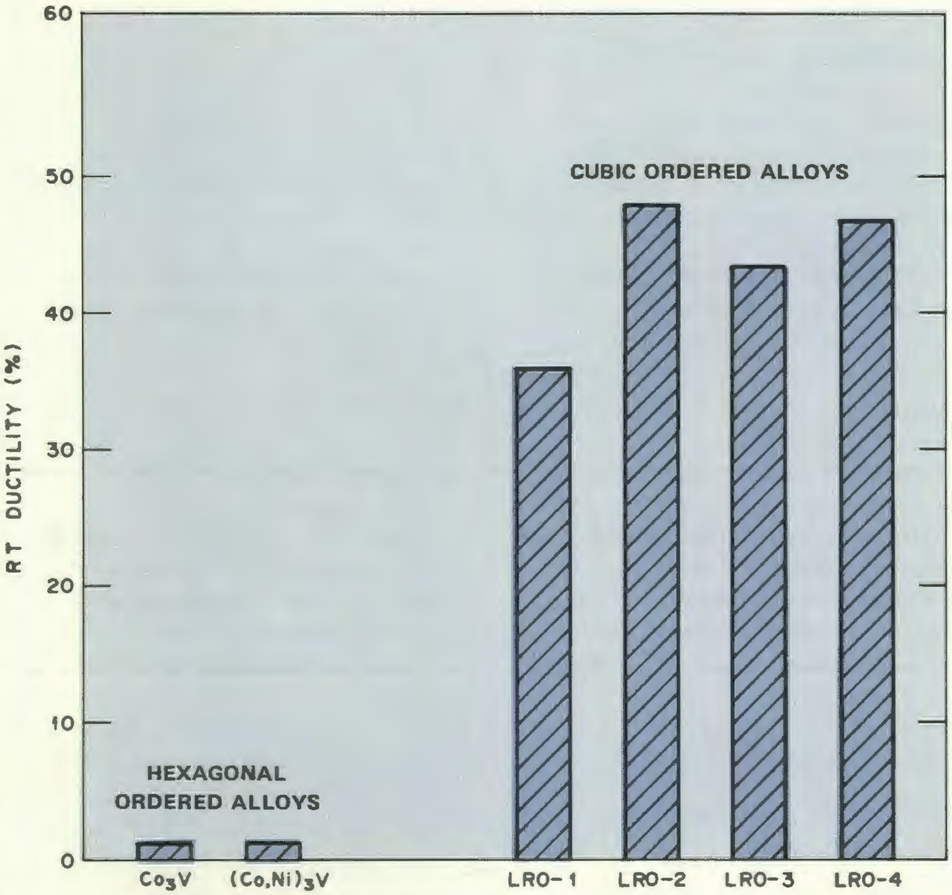
velopment of ordered alloys for high-temperature applications had drawn considerable attention in the 1950s and 1960s; however, enthusiasm for these alloys faded away in the 1970s due to their lack of ductility.

When he left the library for the laboratory, Liu began developing an ordered alloy based on vanadium and cobalt because the two constituents have a strong affinity for each other. Atomic ordering of vanadium and cobalt forms a hexagonal structure VCo_3, which is excessively brittle and has no commercial potential. Liu hypothesized that the alloy's ductility might be improved by adding nickel to it, since elemental nickel has a cubic structure and cobalt has a hexagonal structure. He thought that the nickel might shift the cobalt's hexagonal structure to a cubic one and further stabilize it. A cubic structure is preferable to a hexagonal structure particularly in ordered alloys because the cubic one has more slip systems—12 instead of 3. A slip system is the direction and plane in which a material tends to deform; the more slip systems an alloy has, the more plastic it is and the greater its ductility.

But Liu's first try did not work; the vanadium-nickel-cobalt—$V(Ni,Co)_3$—system only formed a cubic-ordered structure (metastable) temporarily and then was transformed into a hexagonal-ordered structure (stable) on extensive aging treatment. However, tests by Liu and Inouye showed that the alloy is resistant to creep and evaporation losses. At this point, Liu's funding for this work was cut off because the space program shifted its interest to noble-base alloys and because, in general, funding was drastically reduced for long-range applied research programs. So his concern with the intriguing problem of ordered alloys collected dust for eight years.

In the meantime, Liu set out to work with Hank Inouye in testing refractory tantalum-based alloys used for cladding isotope heat sources aboard Pioneer 10 and 11, two Jupiter fly-by spacecraft launched by the National Aeronautics and Space Administration in 1972 and 1973. A tantalum-based alloy was also used on the Viking spacecraft that landed on Mars in 1976. For their work on the Pioneer 11 project, Liu and Inouye received a NASA group achievement award. They also collaborated with Tony Schaffhauser and C. L. White in developing improved iridium alloys for cladding plutonium-238 oxide fuel. They developed an iridium-tungsten alloy for the Lincoln Experimental Satellites, two communication satellites placed in orbit in late 1975. And they fashioned a thorium-doped iridium alloy for the Voyager planetary probes launched in 1977.

The goal of their efforts was to develop an improved alloy for the cladding to ensure that the hazardous radioactive fuel not escape into the environment during reentry or after striking the earth's surface in the event of a mishap. Like cooks testing recipes with varying amounts of different spices, Liu and Inouye



Cubic-ordered alloys containing iron are ductile with an elongation of more than 30% at room temperature. In contrast, hexagonal-ordered alloys are extremely brittle (ductility of less than 1% elongation) at room temperature.

learned to control trace additions of certain alloying elements to iridium so that they would not have too much or too little. They found that the proper amounts of the right elements increased the alloys' resistance to embrittlement. The final "recipes" resulted in patents on three different improved alloys used in the space program. For their achievements, Liu and Inouye received an ERDA letter of commendation in 1975 for the development of improved iridium alloys and an ERDA citation in 1977 for their work on the Voyager project.

Effects of Iron

In 1976, interest in ordered alloys as possible materials for advanced energy systems revived. With the encouragement of Chuck Tarr and Glen Newby of ERDA, Liu resumed his work in the hope of finding a suitable high-temperature material for use in an isotope power plant being developed for NASA. After reading technical articles written in the late 1960s describing the structures of alloys with the composition of vanadium, cobalt, and iron, Liu became interested in examining the effects of a varied iron content on the ordered structure and mechanical properties of this new ordered alloy. As he conducted several tests, it soon became apparent to him that the authors of these papers had not studied the mechanical properties of ordered alloys composed of these elements, having merely assumed them to be as brittle as other ordered alloys. In addition, the authors did not describe the effect of iron content on the critical ordering temperature—the temperature limit below which each ordered alloy retains its structure and above which it becomes disordered as do standard alloys.

Liu and Inouye began studying the effects of adding iron to two binary-ordered alloys: VCo_3 (25% vanadium, 75% cobalt) and NVi_3 (25% vanadium, 75% nickel). In replacing some of the cobalt with iron, they found that the alloy's metallic structure is shifted from hexagonal to cubic and that the iron stabilizes the cubic structure. As a result, the alloy exhibited increased ductility and enhanced resistance to embrittlement below a critical ordering temperature. One reason for this shift to a stable cubic structure (which gives the alloy more slip systems so that it is more plastic) is that the replacement of some cobalt with iron lowers the electron density. Cobalt has nine electrons in its outer orbit, whereas iron has only eight; hence, adding iron changes the atom-electron ratio enough to effect an important change in the ordered structure of the alloy. The alloy composition that Liu and Inouye found to be most ductile up to a critical ordering temperature of 950°C is 25% vanadium, 60% cobalt, and 15% iron.

Iron was found to reduce the brittleness in alloys of the vanadium-cobalt system and of the vanadium-cobalt-nickel system. But Liu also learned that too much iron in these alloys destroyed their high-temperature properties. In the vanadium-cobalt-iron system in which iron constituted only 15% of the content, the temperature use was limited to 950°C (compared with a critical ordering temperature of 1070°C for the vanadium-cobalt system alone). Higher iron content reduces the critical temperature to about 700°C.

Serendipity

Tests of these new superalloys devised at ORNL yielded some pleasant surprises. When these materials were tested at elevated temperatures for yield strength—a measure of the stress level at which the material starts to undergo plastic deformation—the LRO alloys exhibited unusual mechanical behavior. Their strength, instead of decreasing with test temperature as in conventional alloys, increased with temperature as an effect of their ordering. It was found that the hotter they get, the stronger they become up to the critical temperature (700 to 950°C). These new superalloys also show superior tensile strength—the maximum stress a material can tolerate without fracturing.

But most interesting and surprising of all was the ductility of this new class of ordered alloys. If a 1-in. strip is stretched to 1½ in. before failure, it is said to have an elongation of 50%. VCo_3, with its poor ductility, has about 1 to 2% elongation. But the modified superalloys containing iron have greater than 40% elongation at room temperature. Such ductility means that these new alloys are capable of being fabricated by conventional means into complicated shapes such as containment vessels, piping, and heat exchangers. The combination of excellent strength and adequate ductility makes this new class of alloys unique for high-temperature structural applications.

Why does this new class of ordered alloys become stronger with increasing temperatures? Plastic deformation in metals and alloys is governed by dislocations of atoms that move across the atomic layers like waves. The increase in strength with temperature in ordered alloys is mainly due to the change in ordered state with temperature that makes both types of dislocations, single or paired, difficult to move through the lattice without changing the ordered state.

Making of an Alloy

In order to study and test new alloys to determine how well they will withstand a variety of stresses in hostile environments, melts must be made and distributed to experts in specialized testing. Fortunately, a multidisciplinary laboratory such as ORNL has the capability for both fabricating alloys and testing many of their properties.

Ever since the harnessing of the atom, new alloys have been explored, not only for making weapons but also for building better nuclear power reactors. ORNL's involvement in this work has been extensive. In 1958, Inouye and others developed INOR-8, a nickel-based alloy designed to withstand the high operating temperatures and corrosive fluids characteristic of the Molten Salt Reactor Experiment. This alloy's only problem was its potentially short service life due to embrittlement from long-term neutron irradiation. Pratt and Whitney now uses this alloy in aircraft engines for the Boeing 747. In the 1970s, ORNL developed a low-swelling, radiation-resistant alloy of stainless steel for the fast-breeder reactor program. Fuel-pin wrapper cans fabricated from this modified alloy are being tested in the Fast Flux Facility at Hanford, Washington. ORNL is also developing a ferritic steel for potential use in piping liquid metal in breeder reactors.

At ORNL, alloys are made by the conventional process of melting two or more metals together to form a more or less homogeneous mixture. After the metals in powdered or chunk form are melted, the mixture is cast into a melt, such as a 5-in. ingot. Melts are then heated to a high enough temperature to be rolled into sheets. Cold-rolled sheets of alloyed metal tend to be hard and less ductile, so they have to be heat-treated, or annealed, to make them soft and plastic enough to form complicated shapes such as parts of reactor vessels.

Historically, LRO alloys have had to be fabricated well above the critical ordering temperature because they had to become disordered before they could be shaped. This lack of ductility of most LRO alloys in the ordered state has been overcome by the ORNL development of the new alloy system based on vanadium, cobalt, nickel, and iron. As a result, conventional methods can now be used to fabricate this new class of ordered alloys. Forming studies have demonstrated that the alloy sheets can be fabricated without difficulty at room temperatures into hemispheres and thin-walled tubes.

Chain Liu prepares to mount a weight to be suspended from the test alloy. Weights are used in creep tests to determine how resistant materials are to deformation when stress is imposed.

The Tests

In the areas of yield strength, tensile strength, and ductility, the new alloys score high. In addition, tests show that they exhibit superior resistance to "creep"—the extent to which a material is elongated at high temperatures when a weight is hung on it. Says Liu, who conducted the tests: "Our alloys have been found to be 1 to 3 orders of magnitude more resistant to creep than is 316 stainless steel." Other tests have shown that these alloys are resistant to evaporation loss and aging embrittlement which occur commonly in commercial superalloys. Thus, an ordered alloy with a critical ordering temperature of 700°C could be used in fusion devices if it is found to be resistant to radiation damage. "We have sufficient background to lead us to believe that these ordered alloys are more resistant to radiation damage than are standard alloys," says Inouye. He cites work here by Ray Carpenter and Edward Kenik, whose transmission-electron microscopy studies of the brittle ordered alloy of nickel-molybdenum (Ni_4Mo) showed that it is resistant to radiation damage. And he mentions the research at the Chalk River Laboratory in Canada where the ordered alloy of zirconium-aluminum (Zr_3Al) showed no swelling, voids, or other displacement damage after being exposed to electron bombardment.

More tests are in the works at ORNL to verify the hypothesis that ordered alloys such as ORNL has invented are resistant to radiation damage. Ken Farrell will be doing ion bombardment tests of the ordered alloys at the Van de Graaff accelerator; use of heavy ions inflicts damage equivalent to that caused by neutron radiation, but in a much shorter time—a matter of hours, not years. A test of longer duration, started under the direction of Everett Bloom, is the in-pile experiment at Oak Ridge Research Reactor in which tensile specimens of the new alloys will be subjected to neutron irradiation for one year.

Corrosion tests are also under way. Jack DeVan and Pete Tortorelli are conducting tests to determine the new alloys' resistance to liquid-metal corrosion; such information is important in assessing the possible applicability of these alloys for fast breeder and fusion reactors. Inouye is performing helium corrosion tests on ordered alloys as well as Hastelloy X, Incoloy 519, HK-40, and two stainless steels to determine their resistance to impurities in helium used as the coolant in high-temperature gas-cooled reactors. Impurities in helium—typically methane (CH_4), carbon monoxide (CO), and carbon dioxide (CO_2)—can cause carburization of metallic structures, which renders them brittle. Inouye will be measuring the carburization rate of each test alloy over a period of time.

Knowledge about the physical properties of these new alloys could shed light on their thermal-shock behavior—that is, their response to rapid drops in temperature. Tests being conducted on these alloys' physical properties include:

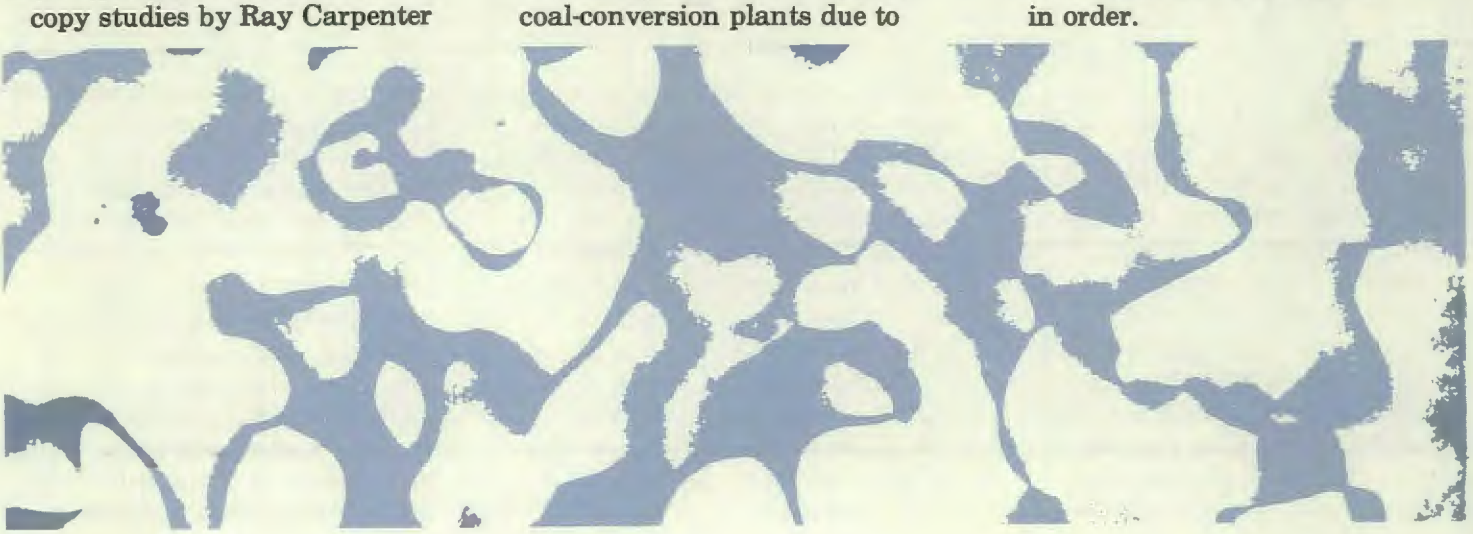
- Neutron scattering studies done by Joe Cable of the Solid State Division to determine the magnetic properties of ordered alloys.
- Studies by Dave McElroy of the M&C Division of the thermal conductivity, thermal expansion, Seebeck coefficient, and electrical resistivity of ordered alloys.
- Transmission-electron-microscopy studies by Ray Carpenter and Dave Braski of the M&C Division to determine microstructure and its correlation with physical and mechanical properties.
- X-ray studies by Cullie Sparks and Harry Yakel of the M&C Division to determine the details of structure such as the relative location of vanadium, cobalt, and iron atoms in the lattices.

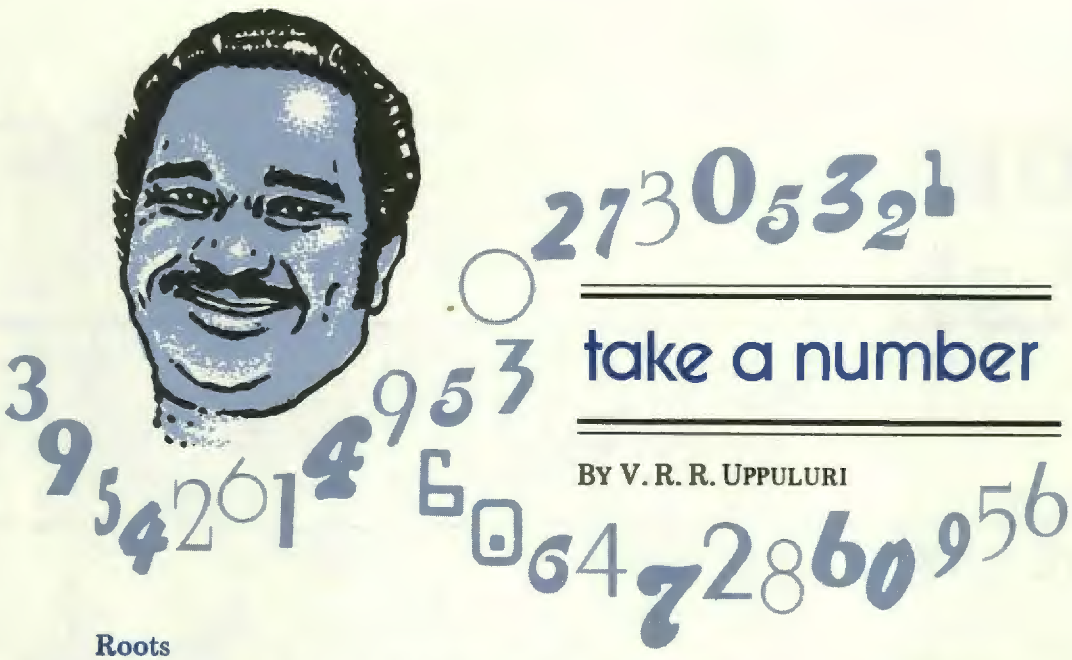
Schaffhauser, who manages the whole long-range ordered-alloy program, is arranging a subcontract with Rensselaer Polytechnic Institute for fatigue studies on LRO alloys.

Based on what is known so far, it appears that ordered alloys developed at ORNL could be used as structural materials for LMFBRs, HTGRs, space power plants, and fusion devices. However, more tests are needed of the alloys' properties, such as resistance to steam corrosion. Unless these alloys are found to be resistant to steam corrosion, they cannot be used for turbines and tubes in steam-generation systems and may be limited to intermediate heat-exchange systems.

It is expected that the current LRO alloys cannot be used for coal-conversion plants due to their inability to resist attack by sulfur and oxygen. The oxidation rate for LRO alloys is higher than it is for stainless steels. Stainless steels contain chromium, which reacts with oxygen in air to form a protective oxide film that slows down the rate at which the alloy is consumed by oxygen. Chromium and aluminum generally improve an alloyed steel's resistance to oxidation, but adding chromium or aluminum to LRO alloys does not markedly enhance their oxidation resistance. The ordered alloy of nickel-aluminum (Ni_3Al) exhibits oxidation resistance, but this material cannot be fabricated easily due to grain-boundary fractures that render it brittle.

"Every alloy should be tailored to a specific application," Inouye says. "Good alloys often have been put to the wrong use. This concept of a new class of alloys has not yet been sold to industry. We have to persuade potential users that these alloys will do them good." In an age when we must turn to advanced high-temperature systems to stretch our energy supplies, industry may soon recognize that exploitation of this new class of LRO alloys is in order.





take a number

BY V. R. R. UPPULURI

Roots

The square root of a positive number N is denoted by $N^{1/2}$ (or $\sqrt{N}$) and we all know how to find it. The following is a simple algorithm that finds $\sqrt{N}$ relatively fast. Let $x_0 > 0$ be a guess of the answer. Divide N by x_0, and add x_0 to the result; divide this total by 2 and call the result x_1. Thus

$$x_1 = \frac{1}{2}\,[x_0 + (N/x_0)]\ .$$

Repeat this process. After the m^{th} stage we have

$$x_m = \frac{1}{2}\,[x_{m-1} + (N/x_{m-1})]\ .$$

We quit when the magnitude of the difference $x_m^2 - N$ is as small as we please and say that x_m is equal to $\sqrt{N}$. This answer is independent of the initial guess. In practice, the answer is obtained in relatively few steps.

This method can be extended to find the cube root of a positive number N denoted by $N^{1/3}$. Let $x_0 > 0$ be the guess. Divide N by x_0^2, and add $2x_0$ to the result; divide this total by 3 and call the result x_1. Thus

$$x_1 = \frac{1}{3}\,[2x_0 + (N/x_0^2)]\ .$$

Repeat this process. After the m^{th} stage we have

$$x_m = \frac{1}{3}\,[2x_{m-1} + (N/x_{m-1}^2)]\ ,$$

and x_m for large m will be close to $N^{1/3}$.

This method can be generalized to find the p^{th} root of a positive number N denoted by $N^{1/p}$. Beginning with any $x_0 > 0$, the sequence

$$x_m = 1/p\ [(p-1)x_{m-1} + (N/x_{m-1}^{p-1})]$$

will converge fast to $N^{1/p}$.

Metals from Fly Ash

Enough Aluminum to Stop Imports

By RONALD M. CANON

Huge quantities of coal residue are produced each year in the United States, primarily from coal combustion. The major producers at this time are coal-fired electric power plants. These plants collected 60 million tons of coal ash in 1975. Coal ash production, tied as it is to the consumption of coal itself, may be expected to climb to 100 million tons by 1985, if the stated goal of doubling our coal usage by then is accomplished. In fact, only six materials are produced in larger quantities than coal ash in this country, one of these being coal. Also expected to increase are the coal residues from pretreatment processes. Coal-washing facilities are now being built to remove the sulfur-bearing pyrites before combustion. Plants where this is done will produce residues containing large amounts of sulfur and iron, as well as significant quantities of carbon. The experimental facilities that are burning coal in fluidized-bed burners that use limestone to remove sulfur as it is released are expected to produce a coal ash physically and chemically different from that produced in conventional power plants. Added to these residues will be those produced by a host of coal-conversion facilities, including coal-gasification and coal-liquefaction plants, and other beneficiation methods.

In short, there is no doubt that, regardless of how coal is consumed to produce power or other fuels, its use will result in the production of large quantities of residue. Disposal of this residue is currently causing problems for utilities, primarily due to the large volumes involved. There is, as well, increasing environmental concern that certain leachable materials in the ash and residue may make disposal far more difficult. Chuck Boston of the Energy Division and Bill Boegly of the Environmental Sciences Division are now investigating the leachate from a number of coal residues, including gasification ash.

Constituents

Coal ash from power plants is generally classified as bottom ash, boiler slag, and fly ash. Bottom ash is the coarse material that falls through the bottom grate of the burner, and boiler slag is the molten ash that collects at the bottom of boilers. Fly ash is the finer material that can be seen coming out of the stack, unless it has been collected

Ron Canon has been a member of the Chemical Technology Division's research staff since coming to ORNL in 1974. He is a chemical engineer, having received his Ph.D. degree from the University of Missouri-Rolla. Prior to his current assignment in the resource-recovery program, he has been involved in a number of areas within the Chemical Engineering Research group. These include experimental efforts in the combustion of graphite (HTGR related), operation of a thermal-energy storage device utilizing a phase-change material, and, more recently, in development work on the Continuous Annular Chromatograph, which received an IR-100 award in 1978. He is presently active in chromatography as well as resource recovery from coal residues. He reports here on one of the newer programs at ORNL, one which has achieved significant progress and is expected to grow in the years to come. Here he discusses the work with Warren Sissom (right) at the sintering furnace.

by electrostatic precipitators. Of the 60 million tons of ash collected in 1975, about 70% of it was fly ash.

In recent years, uses for ash have greatly increased, largely through the efforts of the National Ash Association. Ash is used mainly as a cement additive, a building aggregate, and a road and land fill. More than 16% of the ash produced today is used in these ways, but this 16% is principally bottom ash and boiler slag. The great bulk of unused material is fly ash. It is on this material that we have concentrated our efforts at ORNL.

Coal ash contains from 15 to 30% alumina, 7 to 20% iron oxide, and 1 to 2% titania. The remainder is mostly silica (45 to 55%), with smaller amounts of manganese, chromium, molybdenum, lead, uranium, and many other metals. Recovery of aluminum is probably most attractive, since it is in the largest quantity and is an imported material whose price is largely controlled by an international cartel, the International Bauxite Association. While this group does not yet have the power of OPEC, its members are well aware of the strength of their position. Bauxite ores normally contain more than 70% alumina, whereas coal ash cannot be considered a high-grade ore. Indeed, many clay materials have been found to contain higher concentrations of alumina. However, coal ash does have one very significant advantage: it requires no mining. The raw material costs for coal ash can be calculated to be at least zero, if not negative. Current costs to utilities for ash disposal average about $4 a ton and are expected to rise significantly. The U.S. currently imports about 9 million tons of bauxite a year. A 100% recovery of the aluminum present in the fly ash produced in the United States today would reduce this importation to zero. The Resource Conservation and Recovery Act (RCRA) passed by Congress in 1974 is essentially a federal pollution-control document. It charges the Environmental Protection Agency with setting standards for solid waste disposal. (Emily Copenhaver, analyst in ORNL's Office of Environmental Policy Analysis, is currently involved in determining some of these standards.) RCRA will be applied to all industries except mining, which has only a temporary exemption, and will require classification of solid wastes as nonhazardous or hazardous. If coal ashes are classified as hazardous wastes (based on leaching studies now under way), the cost of their disposal will increase tremendously. Estimates for the cost of disposal of hazardous wastes run from $40 to $100 per ton. ORNL consultant Dennis Weeter (UT professor of engineering) is involved in determining some standards and their impacts on the industry. If costs escalate to this extent, any process which can produce a salable product and a nonhazardous waste will be in wide demand.

Various schemes for recovering aluminum from fly ash have been proposed over the years. In general, such methods have succeeded in recovering about 70% of the aluminum but have suffered economically in competition with the ready availability of cheap bauxite ores. Recovery of metals from fly ash is hampered by the chemical nature of the ash, which is a high-fired material, having been exposed to temperatures of 3000 to

The ceramic characteristics of fly ash make it difficult to process for metal extraction.

3300°F in the power-plant burner—making the ash more like fire brick than anything else. Les Hulett and Bill Lyon of the Analytical Chemistry Division have put an enormous amount of work into investigating the basic structure and composition of fly ash. The particles are mostly spherical and glassy, with sizes ranging from infinitesimal up to about 60 microns. A few particles are hollow and appear to contain other, smaller particles. The hollow spheres have been put to use as insulating material. These silicate bubbles float on the surface of settling ponds and are collected for sale. The bulk of the fly ash (90 to 99%) is solid and is made up mostly of metal silicates. These compounds are extremely resistant to chemical processing. They are unaffected by strong caustics and are only moderately attacked by acids. These qualities of fly ash have led to the development of several sinter-leach operations that are designed to break the metal-silicon bonds by sintering (i.e., heating to a coherent mass) with selected reagents and then leaching out the metals with various solutions.

ORNL's Program

Our program in resource recovery from coal residues began less than two years ago with funds supplied by the Exploratory Studies Program, largely through the efforts of Vic DeCarlo. Forrest Seely and Jack McDowell are playing major roles in the chemical development of new resource recovery processes, while Chuck Scott, Jack Watson, and Keith Brown contribute significantly to the program direction and management. The early success attributable to these people has enabled us to secure funding from the Chemical Science Division of DOE for a continuing program on resource recovery. Tests were conducted with some of the old processes, including the "lime sinter" and "lime-soda sinter" processes. The results showed aluminum recoveries of about 70%, as others had achieved. These processes also produce large quantities of cement. Indeed, the quantity of cement that could be produced in this manner is considerably larger than current U.S. requirements, making its value in this regard questionable. Moreover, the processes involve a large number of steps, and they do not recover other metals, such as iron and titanium. The direct-acid leaches show recoveries of only about 60% for several metals, including aluminum, so other methods were needed to give higher recoveries.

A general survey of possible sintering mixtures revealed two of particular promise, resulting in the proposal of two new processes now being developed at ORNL. The first is the "salt-soda sinter" process, which, as its name suggests, uses salt and soda ash in a

Jack Watson manages the resource recovery work described here.

sintering operation as the first step. Subsequent leaching with nitric acid can recover about 95% of the major metals (aluminum, iron, and titanium) and as high as 90% of the trace metals. This process has the additional advantages of using a lower temperature for the sintering step and fewer processing steps. Its major disadvantage is probably the potential for corrosion from the chloride ion and the precautions necessary to meet nitrate release standards.

The second process discovered at ORNL now appears to be the most attractive. It, too, is a sinter-leach process, and uses calcium sulfate and calcium carbonate as the sintering reagents. Dubbed by its developers as the Calsinter process, it uses a sulfuric acid leach to remove about 98% of the aluminum present and more than 90% of many other metals. Calsinter reduces the solids volume to be disposed of by about 60%, and produces a solid that is essentially calcium silicate and calcium sulfate.

The Calsinter process has another, unique advantage over all the rest. Many utilities are now installing flue-gas desulfurization (FGD) equipment on their stacks to enable them to meet federal standards for sulfur dioxide (SO_2) emissions. Most of these systems are lime or limestone scrubbers, in which a slurry makes contact with the stack gas, absorbing the SO_2. This results in the formation of calcium sulfite and calcium sulfate, along with the unreacted lime. We have used this material, commonly called FGD sludge, or scrubber sludge, as a replacement for calcium sulfate in the sinter mixture. When substituted on a one-to-one basis, no change in metals recovery is observed. The importance of this substitutability becomes apparent in light of the fact that a typical power plant with precipitators and scrubbers will produce fly ash and FGD sludge in approximately equal amounts. To carry the point further, unless methods such as Calsinter are developed for the processing of sludge, there will be a disposal problem almost as large as that created by fly ash.

Future Objectives

The major objectives of the ORNL program for the near future can be lined out about as follows:

- Bench-scale facilities to process kilograms of material (instead of grams) will be installed for further development of the Calsinter process and for determination of the proper engineering course. This step is intended to fill the gap between laboratory data and pilot-plant scale, providing the necessary data for the design of such a pilot plant.
- Chemical and engineering development of the separations methods to be used downstream of the leach step will be pursued. Separation and removal of aluminum, iron, and titanium from the liquor is now being explored.
- A preliminary cost estimate will be prepared for a large, commercial plant using the Calsinter process. This plant would be capable of processing a million tons of fly ash a year, which is equivalent to the output of two large generating plants.

These and other processing methods will be applied to other coal residues. In the coming

Jack McDowell shows Canon the fly-ash pellet ready for sintering.

Kevin Felker watches Forrest Seeley as he compresses the fly ash into a pellet.

years, gasification and liquefaction plants, as well as fluidized-bed combustors, are expected to become more common, and the coal residues produced by each are likely to have different properties. Work on the ash from hydrocarbonization char has already begun, and preliminary tests indicate that the sintering step may not be necessary for that material. A direct leach with sulfuric acid appears to be quite effective.

As more utilities turn to coal washing for removal of high-sulfur particles, the wastes from these facilities will become a problem. We intend to study these materials, and they will be quite different from the ashes. Their carbon content will be higher, but they should be more easily processed since they have not been fired.

We are initiating studies to determine the fate of trace metals in the Calsinter process. Since some of these materials could lead to classification of wastes as hazardous, it is important that their paths and exit points be defined.

Summary

There are two objectives in the resource recovery program. The first is to develop processes capable of recovering significant amounts of valuable materials from coal residues, and the second is to produce a solid material with these processes which can be sold or disposed of at lower cost than can the untreated coal residue.

If solid wastes are produced, it seems likely that the result will be less residue, as well as less that is likely to be declared hazardous.

Development of the Calsinter process promises to achieve both goals. Further development will refine the separation steps of the process and will determine what process modifications are necessary to realize these objectives at an affordable cost. This program is attracting increasing interest from DOE's Basic Energy Research and Conservation programs—and from the Electric Power Research Institute, which is particularly interested in the fate of trace metals.

lab anecdote

Safety on the Job

The job of the safety specialist is a humorless one. He has to fight the machines, the operators, and the other safety specialists. "Safety" Smith was humorless. And those of us here during the War remember only his nickname; perhaps he had a first name, but it was not generally known. Three experiences will attest to his tribulations.

I had a small motorized jeweler's saw to cut ultrapure graphite rods. He worried for the safety of my hands during the cutting procedure, but his several suggestions for saw guards would have broken the rods or introduced impurities—or so I said to him, whereupon he turned to his assistant and declared, "Sometimes it doesn't pay to worry about these things," and walked out of my lab, still unsmiling.

Ed Bohlmann once achieved violent ebullition of an acid mixture; that is, he inadvertently made some acid suddenly boil, and it splashed in his face. Nothing went right after that. There was a delay in getting a phone call to the proper first aid station because there were two first aid stations, one for construction and one for operations. The ambulance driver came to an emergency exit door near Ed's lab but couldn't get in because it was locked by the security department; in those days there was a security guard at only one door of the building, and he didn't have keys for the other doors. Fortunately, Ed's friends found a working safety shower to pour its icy water on his face and shock him. Ed believes that Safety Smith wrote a half-inch-thick report on what shouldn't happen again. He thinks it may still be on file somewhere.

Jim Stangby, administrative assistant in the Chemistry Division, wrote a memo on how Safety Smith had unknowingly breached wartime security. Smith had placed a safety message on an outdoor sign near the exit gate. The sign showed the safety record, and it was a good one, expressed as an accident frequency (accidents per million man hours) and the number of accidents in the past year. A simple calculation would reveal the number of employees at the Laboratory, a number that was restricted information during the War, one that could not be published anywhere else.—*Herbert Pomerance*

BOOKS

At Last—A Really Helpful "How-to" Book for Secretaries

***"Practical Secretary's Manual and Guide,"** by Yvonne Lovely. Parker Publishing Company, Inc., West Nyack, New York, 1978. 212 pages, $10.95. Reviewed by LaWanda Estes Klobe, a CPS and a former executive secretary at ORGDP, now in the Engineering Physics Division Reports Office.*

It is a temptation to subtitle my review "How to Get the Most Out of This Great New 'How-To' Book for Secretaries and Executives," because this book can certainly be of help to both.

Since the work of a secretary is 95% detail, it is not possible to write a guide for secretaries in general terms. And it is not easy to write a book on details that is interesting, informative, and fast, easy reading. So I am pleased and relieved to report that Yvonne Lovely has done just that. I am pleased because such a guide is needed, and I am proud of her accomplishment; I am relieved because reviewing a book written by a long-time friend is *much* easier if you like the book!

Lovely has managed to condense within her book a complete outline and review of the attitudes and efforts required of secretaries who aspire to a CPS-level performance and job. It is not a reference book, although it does contain some reference material. It is basically a "how-to" book covering all aspects of secretarial work and office administration.

While no single job will require all the systems and tips to be found between the covers of Yvonne Lovely's book, a thorough first reading (which will take an amazingly short time) will provide a wealth of ideas for application in any office. Some sections of this guide may seem overly elementary and detailed to any secretary with more than a year or two of experience, but do not dismiss a review of the basics too quickly. You may be reminded of very useful but long-forgotten time-savers and problem solvers. Almost every page offers some new idea for consideration.

Yvonne Lovely

To executives I offer the following practical guide to the new practical guide for secretaries:

Citizens who do not vote deserve bad government; by the same token, those executives who tolerate poor secretarial performance without question or complaint deserve bad secretaries. Some secretaries will learn from experience, while others will be driven by sheer frustration or laziness to "find a better way." If one or another of the functions of your office is unsatisfactory or downright annoying, and if your secretary has ignored all hints that she do something to solve the problems, then I urge you to turn to this book for help. In a matter of minutes you can read up on some simple ways to handle specific office functions. For instance, if your phone messages are lost, incomplete, or garbled, try reading Chapter 1.

But even if you haven't the time or the inclination to plow through just one chapter, I do suggest five minutes' reading beginning in the middle of page 161. This description of the I-Can-Do-It-Myself and the I-don't-know-what-to-expect-of-a-competent-secretary executives should give almost everyone food for thought. Happily, very few executives, junior or otherwise, possess more than a minimum number of the tragicomic habits and faults so tellingly described in the chapter on handling problem situations.

Notwithstanding one minor quibble I have with the author's advice regarding the positioning of special text material, the information contained in this book could be used by all secretaries as a point of departure to stimulate the development of the unique systems and solutions required to achieve the best possible operation of each individual office. I recommend the "Practical Secretary's Guide and Manual" to anyone who is involved in the operation of an office.

A Guide to Feynman Diagrams in the Many-Body Problem, *by R. D. Mattuck. McGraw-Hill, Inc. (New York), 1976. 335 pp + appendices and index, $20. Reviewed by Len Gray, research mathematian with Computer Sciences Division.*

As a nonphysicist who has, in the words of the author, "trembled with awe when a many-body theoretician covered the blackboard with Feynman diagrams," I am a member of the audience for whom this book was written. Reading it will not qualify you to speak fluently in the language of Feynman diagrams, but you will have some idea of what is being said when you hear the language spoken.

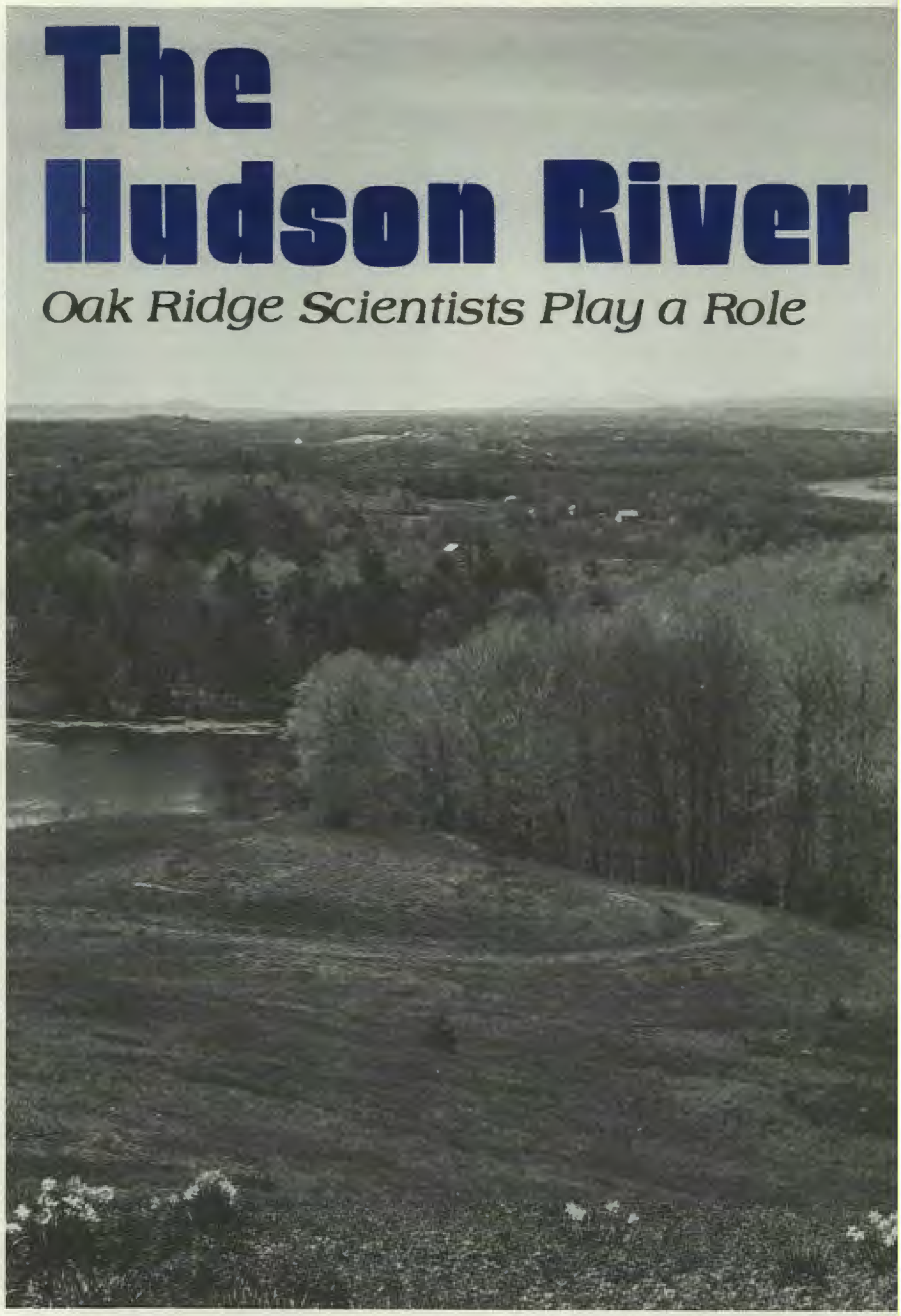
In the first third of the book, labeled the "kindergarten section," the general many-body problem is introduced, and it is shown how solutions to simple problems can be obtained "merely" by drawing these strange pictures. The basic ideas are explained carefully, and usually several times (anyone who knows anything about Feynman diagrams will probably find this tedious and insulting). Those who do not faint when confronted with a Green's function or "propagator" can read this section easily and profitably.

The remaining two-thirds of the book, of which I have only read selected parts, requires more familiarity with quantum mechanics and more dedication on the part of the reader. In the elementary section, topics which were previously discussed in comic book terms are treated more formally, and more detailed computations are carried out. The intermediate section deals with the application of Feynman diagrams to specific problems, such as superconductivity and phase transitions. This last third of the book contains the most interesting material in that some of the major triumphs of the diagram method are discussed. It is, also, the least accessible to the nonphysicist.

Mattuck writes in a leisurely, conversational style; if he has a flaw, it is that he sometimes gets carried away with being cute. However, this is a small price to pay for such a readable introduction to a difficult subject.

The Hudson River

Oak Ridge Scientists Play a Role



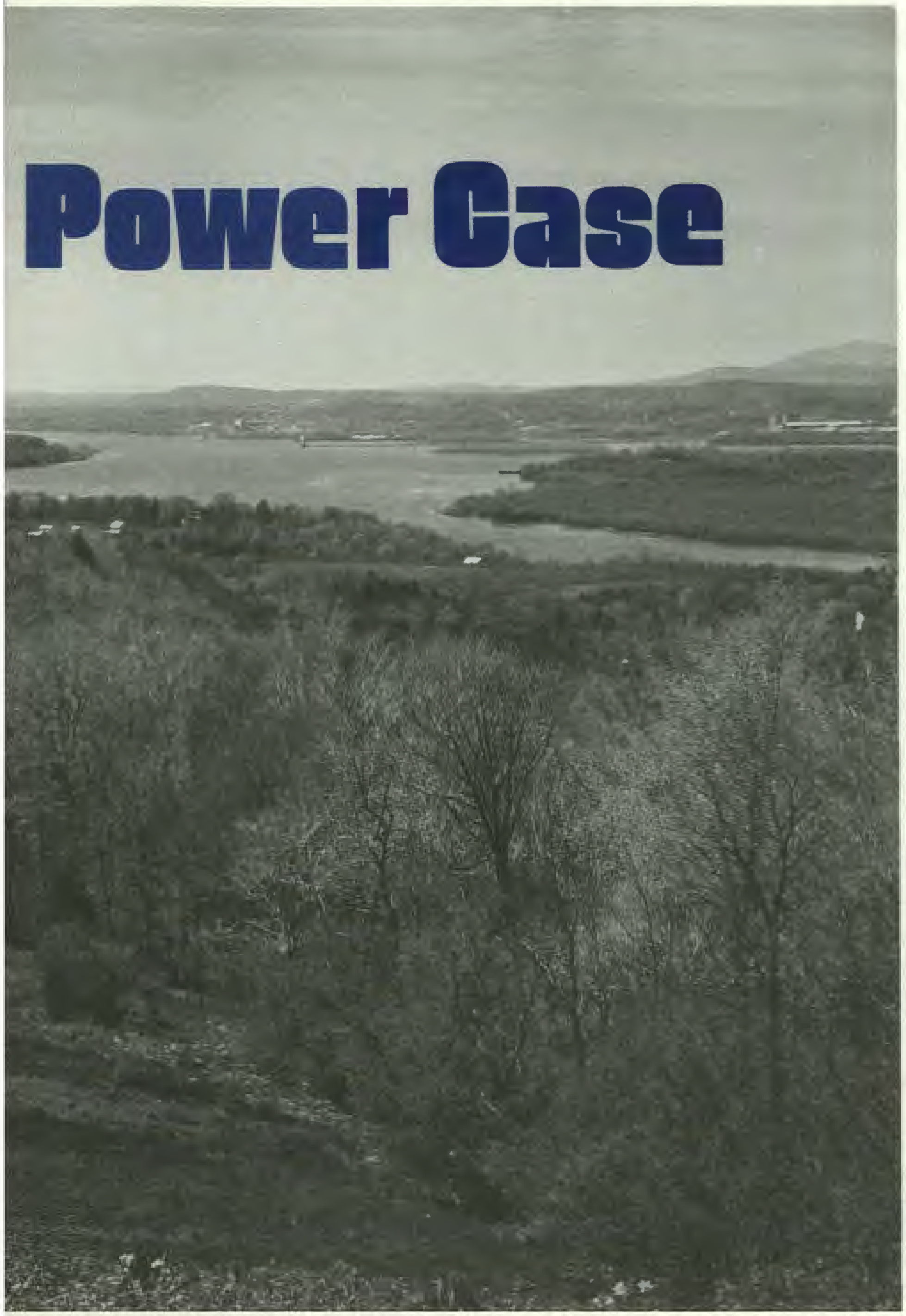
By CAROLYN KRAUSE

The Hudson River has played a legendary role in our nation's history as the first highway of commerce, the birthplace of the steamboat, the home of one of the first railroads, the romantic haven of a school of painters, and the breeding ground for many of the nation's first industries. But the river is also a breeding habitat for the Atlantic Ocean striped bass, which is important for sports and commercial fishing.

And with its scenic mountain vistas the Hudson River attracts New Yorkers seeking a peaceful retreat from big-city life. So it is not surprising that in the 1960s the river became one of the major battlegrounds on environmental issues in the wake of proposals by utilities to build more power plants on its banks to keep pace with demands for electricity. Fifteen years after the first protests were voiced, the environmental war still drags on, and Oak Ridge National Laboratory continues to be one of the many participants in the scientific battles.

In September 1962, Consolidated Edison Company of New York, Inc., announced plans to build a pumped-storage hydroelectric plant on Storm King Mountain near the village of Cornwall on the Hudson River. The decision touched off considerable opposition by the affluent residents near the mountain, although the villagers welcomed the plant because of its potential boost to the local economy. Opponents of the plant initially cited aesthetic reasons for not wanting the plant built. They said that the

Power Case



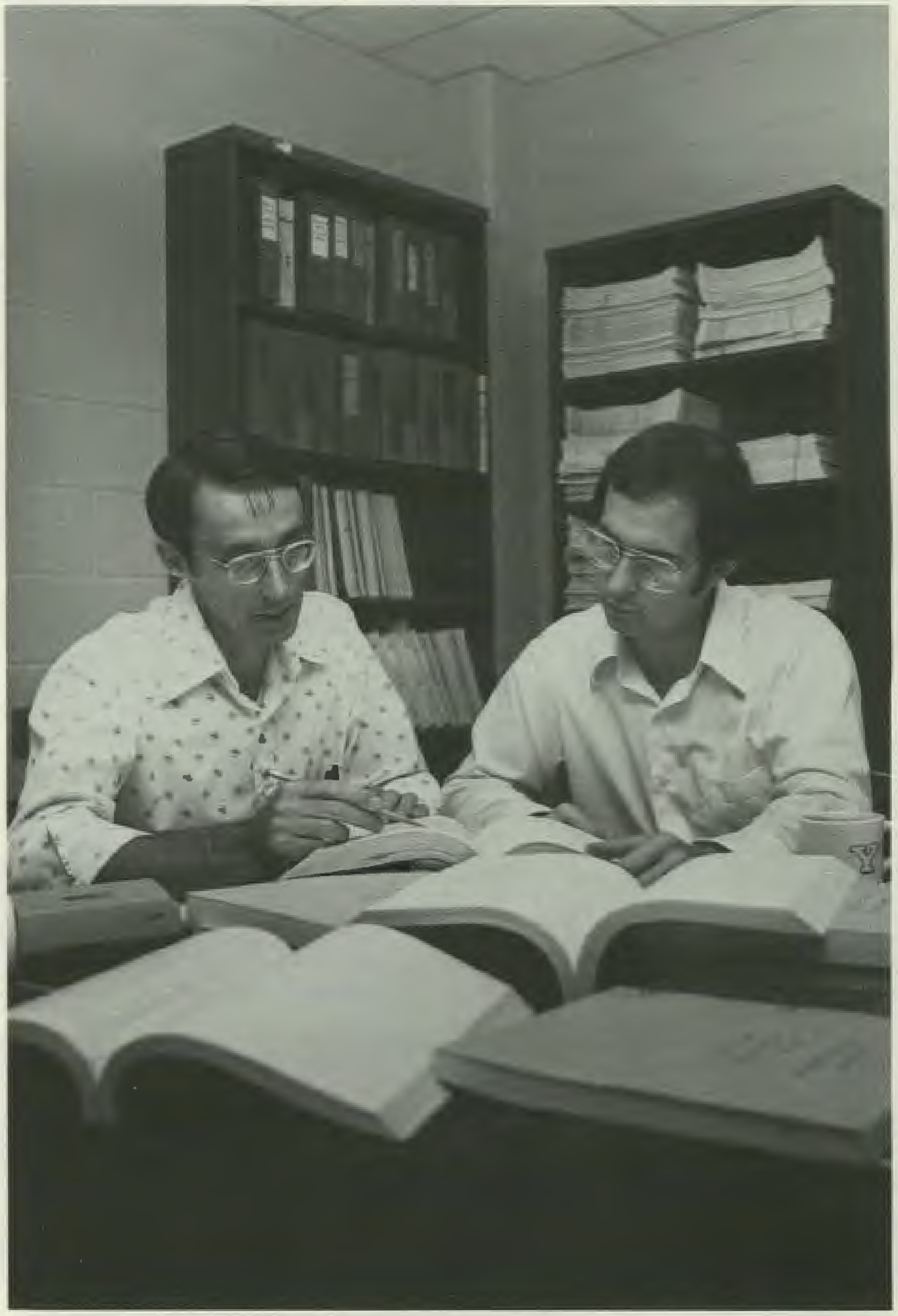
This view of the famous bend in the Hudson River shows one of the areas where the federal government has called for a cooling tower to mitigate power-plant impacts on the river's striped-bass population. Several New York utilities oppose cooling towers, largely because of their cost.

transmission lines would spoil scenery in the highlands and that the two-million-kilowatt plant would leave a huge gash in the mountain, essentially destroying it. The storm that brewed over Storm King Mountain in 1963 was considered by many to be "the birth of the environmental movement." Con Ed tried to accommodate the residents by proposing to put the power lines and part of the plant underground. But by then opposition to the Cornwall plant had mushroomed to the point that the New York newspapers and the city government had joined forces with the intervenors against the plant, which Con Ed said was urgently needed to meet the power demands of the New York City area.

Arguing before the Federal Power Commission, opponents insisted that there were better alternative methods for producing power (such as gas turbines) during periods of peak demand. They stated that the Cornwall plant would cause more air pollution because additional coal would be burned to supply power to pump water from the Hudson up to the storage reservoir (Con Ed denied this, saying that nuclear plants would be the source of power). And opponents pointed out that striped bass and other fish in the water removed for pumping would be killed.

The issue of possible fish kills at the Cornwall plant became the subject of a 1973 hearing held by the Senate Committee on Government Operations, chaired by Senator Abraham Ribicoff of Connecticut. Senator Ribicoff

Webb Van Winkle and Sig Christensen, who supplied most of the information on which the following article is based, have been involved together in the Hudson River Power Case since 1974. A native of Plainfield, New Jersey, Van Winkle is an Oberlin College graduate with a Ph.D. in zoology from Rutgers University. He worked in the Shellfish Research Laboratory at Rutgers, served as assistant professor of biology at The College of William and Mary, and taught in the biomathematics program at North Carolina State University as a National Science Foundation and Public Health Service postdoctoral faculty fellow. After joining ORNL's Environmental Sciences Division in 1972, Van Winkle was named group leader of the Fish Population Studies Project and now heads the Aquatic Ecology Section. Van Winkle and fellow ecologist Christensen have worked together on environmental impact assessments, computer simulation modeling of fish populations, development of entrainment modeling methodologies, and extension and validation of stock recruitment theory. Christensen, a native of Doylestown, Pennsylvania, is an alumnus of Amherst College with a Ph.D. in biology from Yale University. He came to ORNL in 1973 and has been working in Van Winkle's group since 1974. Here Van Winkle, left, and Christensen pore over transcripts of the EPA hearings involving Hudson River power plants.



was particularly interested in the problem because many striped bass that are spawned and hatched in the Hudson spend their adult lives in Long Island Sound where they provide sports fishing for Connecticut anglers. In a September 10, 1973, letter to Dixy Lee Ray, chairman of the Atomic Energy Commission, the senator wrote: "The fishermen fear that the Storm King plant, which will take in nine million gallons of Hudson River water a minute, will also suck in and destroy vast numbers of eggs, larvae, and young striped bass and thus cause the fishing in Long Island Sound to decline drastically."

ORNL and Storm King

Senator Ribicoff had decided to involve the AEC in the controversy because of differing opinions on the fraction of the yearly production of striped bass

"This issue of cooling towers ... has dominated the Hudson River Power Case ..."

that would be destroyed by operation of the Cornwall plant. Con Ed had stated that 3% of the hatch would be lost, but various fishermen and ecologists representing the Scenic Hudson Preservation Conference argued that, if Con Ed had taken into account the tides in the Hudson, the figure could be as high as 35%. After all, eggs and larvae washing back and forth in front of the plant would have a better chance of being entrained than if they only passed the plant once.

"Because of these different opinions," Senator Ribicoff wrote Chairman Ray, "I wish to submit the question of just what effect the Storm King plant would have on striped bass to the Oak Ridge National Laboratory. The aquatic biology section, led by Dr. Charles Coutant in the Environmental Sciences Division, enjoys the finest reputation, and the Laboratory has, most importantly, a biological model of the Hudson used in the Indian Point Unit 2 operating license hearing recently concluded by the Atomic Energy Commission."

Phil Goodyear, ORNL ecologist, received the assignment to provide a preliminary analysis to resolve the conflicting conclusions. His approach was to analyze the methodology that underlay Con Ed's position as expressed in the document entitled "Hudson River Fisheries Investigations, 1965-68 (HRFI)." Goodyear found that the "authors of the HRFI report erred in their method of computing the percentage of eggs and larvae withdrawn at Storm King by omitting consideration of the bi-directional nature of the tidal flow." After identifying another compensating error, Goodyear performed some calculations and concluded that, if the plant operated daily during the period when the greatest number of eggs and larvae are washing back and forth in front of the plant, a substantial fraction of the annual hatch might be destroyed. Goodyear's report, which suggested that the Cornwall plant could significantly affect striped bass fishing in the New York Bight and Long Island Sound, triggered the reopening of FPC hearings on the plant in 1974.

Many people have forgotten the Storm King controversy. But as William Tucker states it in his article "Environmentalism and the Leisure Class" in the December 1977 issue of *Harper's* magazine, the issue of the pumped-storage plant is still alive, "miraculously embalmed in the deep-freeze storage of the court system." Encountering delays and expecting more, Con Ed has resigned itself to not getting the Cornwall plant built and operating until 1992 or later.

Indian Point Hearings

In late 1971, ORNL was first drawn into the so-called Hudson River Power Case after the landmark Calvert Cliffs decision in which a federal judge severely criticized the AEC's implementation of the National Environmental Policy Act (NEPA) of 1969, which requires environmental impact statements for such federally licensed projects as nuclear power plants, including those already in operation. ORNL ecologists were asked to assist in preparing impact statements on Indian Point Units 2 and 3, twin nuclear power plant units on the Hudson River. ORNL prepared the final environmental impact statement on Indian Point Unit 2 by September 1972. A lengthy hearing on this plant ensued, as the AEC's Atomic Safety and Licensing Board (ASLB) heard conflicting testimony from November 1972 through May 1973. In hearings held in Washington and Croton-on-Hudson, Goodyear testified that the thermal and mechanical effects of entrainment and impingement at the nuclear plant could endanger the striped bass population in the Hudson. The ASLB issued a decision calling in essence for the retrofitting of cooling towers by May 2, 1978. The board added that, if in the intervening time the utility's researchers obtained evidence that once-through cooling inflicts no measurable harm on aquatic life, another hearing would be held so that Con Ed could present its case.

The issue of cooling towers versus once-through cooling has dominated the Hudson River Power Case, which now involves two nuclear and four oil-fired operating units at three sites. In

"Ecologists ... in the early 1970s tended to see themselves as knights in armor ..."

once-through cooling, a power plant pumps a large amount of water from the river to condense steam leaving the turbines so that the steam can be recycled into the steam-generation system as water. The relatively cold water removed from the river runs through small condenser tubes which absorb heat from the steam. The river water is then returned to the river as heated effluent, thus raising the temperature of the river in the plant's vicinity. Another problem with once-through cooling felt from the beginning to be more important in this case relates to entrainment and impingement. To prevent fish or other objects drawn in along with the pumped water from clogging the condenser tubes, utilities install screening devices at the intakes. But there is still a biological problem. Small fish, larvae, and eggs are either sucked through the holes in the screens (entrainment) or are trapped against the screens (impingement). These stresses can possibly kill enough fish to have a long-term effect on their population.

To mitigate these stresses on fish and other aquatic life, environmental scientists frequently propose cooling towers as an alternative to once-through cooling. These closed-cycle systems withdraw only 5% as much water, most of which is never returned to the river. The water heated in the process of cooling the condenser tubes is sprayed into the tower (in natural-draft systems) and is cooled by rising drafts of air. Rather than being dumped into the river, the heat in this water is dissipated to the atmosphere by evaporation, with the incidental escape of tiny water droplets. The cooled water is recirculated to the power plant's condenser tubes to remove more heat.

Because the same water is used over and over again to do the cooling, only about one-twentieth the water required for once-through cooling would have to be withdrawn from the river for power plants with closed-cycle cooling. Hence, a smaller fraction of fish would be affected. It should be noted that some small fish and eggs entrained in once-through cooling systems survive, but it is assumed that all fish drawn into cooling towers die from the biocides used to prevent fouling of heat-transfer surfaces. Even so, many environmental scientists believe that the trade-off favors cooling towers.

Objections to cooling towers range from the environmental to the economical. If the water withdrawn for cooling is salty, the salt dissolved in the escaping water droplets can be deposited on surrounding land to the distress of nearby residents. Besides the saline-drift issue, nearby residents may also raise aesthetic objections to cooling towers, because these structures, some of which exceed 500 ft in height, will sometimes have visible plumes, and on the whole will dominate the visual scene of most landscapes. Utilities, of course, may oppose cooling towers on the basis of capital and operating costs which can run into millions of dollars. The cost is an even greater burden for existing power plants designed to use once-through cooling; retrofitting them with cooling towers usually requires a cutback in power output and, hence, reduced revenues.

Appeal Board Critical

When the ASLB told Con Ed it would have to build a cooling tower at Indian Point Unit 2 by May 1978, the utility appealed that decision. In April 1974, the Atomic Safety and Licensing Appeal Board granted Con Ed an additional year before towers would have to be installed. At the same time, the appeal board was critical of ORNL studies on technical grounds. According to Webb Van Winkle, ORNL ecologist: "The appeal board felt that the position taken by ORNL was not justified by the data available and that our position was one of conservatism rather than realism. The board said that ORNL took a conservative, proenvironmentalist stance when what was called for by NEPA was a realistic evaluation. Ecologists preparing environmental impact statements in the early 1970s tended to see themselves as knights in armor on white horses trying to save the day from an environmental point of view. Hence, they took the conservative position because of data that were inadequate or highly uncertain."

For example, Con Ed claimed that the fraction of entrained fish killed by a power plant was

"... we had become identified as a center of expertise ..."

probably less than 50%. But ORNL ecologists took the position that the data were not adequate to show that the mortality was not 100%. So ORNL generally used 100% mortality in their analysis. On other technical issues ORNL and Con Ed were far apart.

"After the appeal board decision in April 1974," Van Winkle said, "high priority was assigned by the Laboratory to addressing the appeal board's concerns and taking a fresh look at the issues flagged by the board. We decided to try to allay these concerns about our analysis of the impacts of Indian Point Unit 2 in the final environmental impact statement on Indian Point Unit 3, which was published in February 1975."

Phil Goodyear, the ecologist originally assigned to Indian Point Unit 2, left ORNL in March 1974 for a job with the Department of the Interior's Fish and Wildlife Service. So Van Winkle was put in charge of the reanalysis of the ecological aspects of the two Indian Point plants. He was joined by Sig Christensen in May 1974.

Con Ed, the Nuclear Regulatory Commission (NRC), and the intervenors signed an agreement in December 1974 stipulating that operation of the unit with the once-through cooling system would be permitted during an interim period ending September 15, 1980, after which the unit would be operated only with an approved closed-cycle cooling system. But Con Ed was granted the opportunity of asking that the hearings be reopened if the utility managers thought the results of the study programs warranted it. [On December 31, 1975, the Power Authority of the State of New York (PASNY) purchased Indian Point Unit 3 from Con Ed, which was having financial difficulties. Con Ed continues to operate the plant for PASNY, and they both work together on legal and licensing issues.]

Con Ed and PASNY asked NRC for a two-year delay for the installation of the Indian Point Unit 2 cooling tower. In 1976–77, NRC held a hearing on the utilities' request for a delay. ORNL prepared a draft and final impact statement on the consequences of a two-year delay, and Van Winkle testified on ORNL findings at the NRC hearing. The hearing board delayed the date for the cessation of once-through cooling at Indian Point Unit 2 from 1979 to 1982.

More Federal Agencies

The Hudson River Power Case, including the Storm King plant affair, had involved so far primarily the actions of two federal agencies: the FPC and the AEC (the regulatory arm of which later became the NRC). But more governmental agencies were preparing to jump into the Hudson River morass.

In 1976, the Corps of Engineers had undertaken to redo its environmental impact statement related to utility requests for discharge permits required for the Bowline Point and Roseton oil-fired generating stations, each of which consists of two units on the Hudson River. Orange and Rockland Utilities, Inc., operates the Bowline Point units, and Central Hudson Gas and Electric Corporation runs the Roseton units. Intervenors claimed that the Corps had not adhered to NEPA's requirements in preparing its original impact statement. So, at the request of the intervenors, the Corps approached ORNL for help.

"Because of our involvement with the NRC," Van Winkle says, "we had become identified as a center of expertise on power plant impacts on the Hudson River. Other governmental agencies began to turn to us for assistance."

To satisfy both the legal requirements and the intervenors, ORNL generated a two-volume report, used as an appendix to the Corps' impact statement, which considers the impacts on the Hudson River ecosystem. The report takes into account the effect of the oil-fired plants on air quality and water temperature, as well as the impacts on aquatic life.

About the same time, ORNL was getting involved with the Environmental Protection Agency. Amendments to the Federal Water Pollution Control Act of 1972 provide for exemption from the requirements of Sections 316A and 316B of the

Bernadette Kirk works at a terminal in a time-sharing session on the PDP-10 computer as Doug Vaughan examines results from simulation modeling of a striped bass population.

act which apply to new power plants as well as to old, large power plants. Section 316A requires that thermal discharges be minimized. Section 316B requires the use of best practicable technology in the design of intake structures. Since this latter requirement has been interpreted to mean that the best technology is that which reduces intake of water from a river to a minimum, both sections may be invoked by activist groups arguing for the use of cooling towers.

"Cooling towers have traditionally been viewed primarily as a means of meeting thermal discharge requirements, of getting rid of the heat to the atmosphere rather than dumping it into the water," Christensen says. "But the EPA case that ORNL is currently involved in relates to the use of cooling towers to mitigate impacts of entrainment and impingement on early fish life."

In 1975, EPA ruled that the four utilities should retrofit cooling towers at six units: two oil-fired units at Bowline Point, two oil plants at Roseton, and Indian Point Units 2 and 3. In July 1977, Con Ed and the other utilities submitted their case to EPA concerning their reasons for feeling the towers are not needed. Since then, ORNL has been heavily involved with the EPA case.

EPA vs the Utilities

Here's the way the position lines are drawn. EPA asserts that the utilities are required to backfit cooling towers to these six existing units on the Hudson River to reduce entrainment and impingement of striped bass and other fish species by greatly cutting back the volume of cooling water withdrawn. Assisting EPA are ORNL, the National Power Plant Team of the Fish and Wildlife Service at Ann Arbor (including Phil Goodyear), and consultants from several universities. ORNL researchers working closely with EPA are Van Winkle, Christensen, Larry Barnthouse, Doug Vaughan, and Bernadette Kirk.

The utilities claim that cooling towers are not needed and are very expensive (they estimate that the ultimate cost of six towers would be almost $1 billion; others point out that this is only roughly 1 to 1.5 mills/kWh). The utilities are Con Ed and PASNY (Indian Point), Orange and Rockland Utilities and Con Ed (Bowline), and Central Hudson Gas and Electric and Con Ed (Roseton). The utilities have spent about $30 million on legal costs and on aquatic ecology studies conducted by their own employees and by outside consultants. Primary consultants to the utilities are Texas Instruments, Inc.; Lawler, Matusky and Skelly, Engineers;

Ecological Analysts, Inc.; New York University; Stone and Webster; and the University of Rhode Island.

Besides the utilities and their consultants, there are many agencies, groups, and organizations involved. In addition to EPA, federal agencies include NRC, the Federal Energy Regulatory Commission, the Corps of Engineers, the Department of the Interior, and the National Marine Fisheries Service. The Commonwealth of Massachusetts is involved as well as the New York State Attorney General's Office, the Public Service Commission, and the Department of Environmental Conservation. Other intervenors (on both sides of the cooling-tower issue) include the Natural Resources Defense Council, the Hudson River Fishermen's Association, the Scenic Hudson Preservation Conference, the Town of Haverstraw, and the Orange County Chamber of Commerce. These nonutility organizations have spent \$2 to \$3 million to date on this case and will probably spend \$1 to \$2 million more by the conclusion of the case, Christensen estimates.

The Forum

At EPA adjudicatory hearings held in New York City, lawyers for the utilities, the federal government, New York State, and for the intervenors have been debating the environmental impacts of power plants using cooling towers versus those using the present once-through cooling systems. So far, the initial cross-examination rebuttals before a judge at these adjudicatory hearings have produced 11,000 pages of transcripts, with 20,000 pages expected by the time the hearing winds down in New York. This is in addition to a body of written testimony (mostly in the form of utility reports) that is more than three feet thick.

The Technical Issues

There are several technical issues on which there is disagreement between EPA and the utilities:

- What is the "cropping factor," defined as the probability that an entrained live organism will be killed due to passing through the cooling system?
- What is the "intake *f*-factor," defined as the ratio of the concentration of entrainable fish at the intake to the concentration in the cross section in front of the plant?
- To what extent does the Hudson River striped bass population resist stress through biological compensation—the ability of organisms to experience better growth and survival at lower densities than at higher densities? Does compensation partially offset the harmful impacts of power plants on fish populations, and to what extent? ("Biological compensation is a key issue in the controversy, and probably the issue that is least amenable to firm solution based on data," says Christensen.)
- What is the contribution of the Hudson striped bass stock to the Atlantic coastal population? Van Winkle is using discriminant analysis on data generated by Texas Instruments to determine the fraction of ocean bass that originated in the Hudson. By collecting striped bass of unknown origin in the ocean and comparing their morphological characteristics (such as the number of scales along the lateral line) with those of striped bass of known origin, ecologists can tell within limits whether the bass were hatched in the Hudson River or in Chesapeake Bay. This information is important for sport and commercial ocean fishing.
- Can stocking the river with striped bass be used as a mitigation measure?

Besides use of discriminant analysis to estimate the contribution of Hudson bass to the ocean stock, ORNL has pursued other research efforts as part of its involvement in the controversy. Ecologists here are developing methodologies for estimating the cropping factor, the intake *f*-factor, and the fractional reduction of young fish that will survive. "For example," says Christensen, "50% of the larval fish might be collected alive from the river in front of the power plant. But at the discharge of the plant, perhaps only 30 or 40% will be collected alive. We have developed a computer model that uses such information to predict what the fractional kill of live larvae will be, recognizing that there are uncertainties associated with such predictions."

ORNL is also using simulation modeling to forecast long-term consequences of power-plant impacts with various assumptions about biological compensation. In addition, the ecologists are employing the Statistical Analysis System (a package of computer programs) to process, format, and analyze large data sets. Christensen has also worked on developing a new stock-recruitment model

"... exhausting, frustrating, ... overwhelming ... exciting ... challenging ... intellectually demanding."

and a technique for validating such models in general. Stock-recruitment models are based on a body of theory proposed by Ricker of Canada and by others in the 1950s as a means of predicting the effects of fishing on a given fish population, so as to estimate how much fishing could be allowed and still have the population maintain itself at a desirable level.

In 1975, Texas Instruments proposed using the stock-recruitment approach to quantify biological compensation for striped bass. In the utilities' first attempt, in 1977, to apply this approach, they made an error in substituting a power-plant exploitation rate for the fishing exploitation term in one of Ricker's equations. ORNL and the National Power Plant Team derived the proper equation. Everyone now agrees on the mathematics, but the usefulness of the stock-recruitment approach for predicting impacts on Hudson River fish is still a matter of considerable controversy.

Ecologists and Lawyers

Christensen, Van Winkle, Barnthouse, and Vaughan have spent numerous days in New York briefing EPA lawyers in preparation for the hearings. Says Christensen: "We assist them with the cross-examination questions they will ask the utilities' ecologists. Sometimes we prepare the questions because the attorney doesn't understand the technical material. After a while, the lawyer becomes familiar with the material and can postulate good technical questions. We're becoming better lawyers, and the lawyers are becoming better ecologists."

In the courtroom, the EPA lawyers are flanked by technical consultants. This can provide some comic relief during a serious hearing. Recalls Christensen: "One time an EPA lawyer asked a witness a question and received an answer that totally baffled him. He didn't know what to do next. I was sitting on his left and Joel Golumbek, a technical advisor with EPA, was on the right-hand side. We both leaned over and started simultaneously whispering suggestions in his ears, one from each direction. I looked up, and the witness had a big grin on his face and began chuckling because he was seeing what we couldn't: our lawyer was looking absolutely confused."

The adjudicatory hearings are presided over by a judge, whose job is to make sure that the hearing is properly conducted and that everything said and introduced as evidence gets into the record. When the hearings are over (probably in 1979), the lawyers for all parties will sum up the arguments in briefs to be presented to the decision maker, the regional administrator of EPA Region II. If his decision is appealed, EPA Administrator Douglas Costle (or his successor) will have to rule on the issue. It is widely felt that the case will wind up in the civil courts and ultimately reach the Supreme Court for a final decision. As it is now, the case is a classic study in environmental impact assessment and a test case for the entire country in connection with implementing Section 316B (intake technology) of the Federal Water Pollution Control Act Amendments of 1972.

The ORNL ecologists have found the hearings to be exhausting, frustrating, and occasionally overwhelming as well as exciting, challenging, and intellectually demanding. They have welcomed the opportunity to interact with other ecologists and to provide scientific input to enable a crucial decision to be made. They have insisted on technical integrity in interpreting and analyzing data and the conclusions of others. And they have been quick to spot the areas that need further research, much of which could be competently performed at ORNL.

There are moments, however, when Van Winkle wishes that the whole matter could be settled with the speed and certainty of an athletic contest. He recalls a doubles tennis match in Ann Arbor, where he and Jack Mattice, another ORNL ecologist, played a biologist with Con Ed and a consulting engineer to the utility. "We think we won one cooling tower at Indian Point in that match," says Van Winkle.

Complex technical issues are not resolved on the tennis court. Still, as the utilities and the ecologists continue to work it out, both sides may eventually win a real victory in the improved, environmentally acceptable energy systems of the future.

information meeting highlights

CHEMICAL TECHNOLOGY, August 24 and 25

A Device to Detect Coal Plant Spills

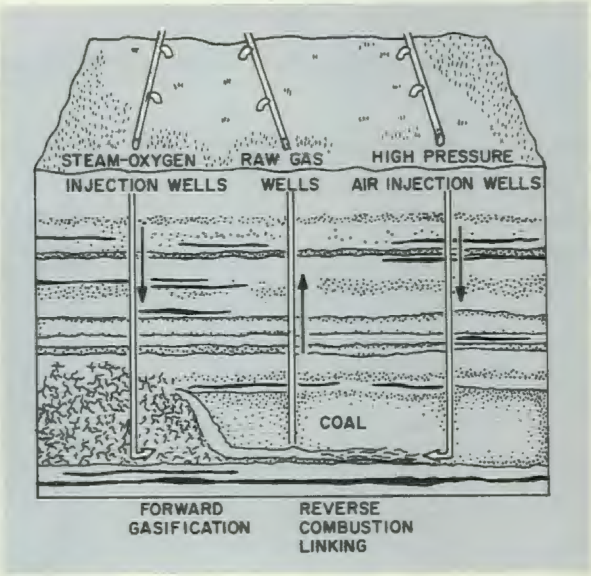
Is the flange contaminated with polynuclear aromatic hydrocarbons? Technician Guy Jones checks it using the prototype of the newly developed, portable fluorescence spotter, as Dan Schuresko looks on.

Products and wastes from coal-gasification and coal-liquefaction plants contain polynuclear aromatic hydrocarbons (PNAs), some of which may cause cancer in man. New technology is needed for remote detection of leaks and spills of such potentially hazardous substances in order to provide a ballpark estimate of the amount of PNA material in the working environment, which will help determine what cleanup measures are appropriate, and to check whether the site of the accident is completely decontaminated. In the nuclear world, the Cutie Pie survey meter is used to detect radiation leaks and spills of radioactive materials. Now the coal world may soon have the counterpart of the Cutie Pie, thanks to a new ORNL development.

Dan Schuresko of the Chemical Technology Division and several associates have developed a portable fluorescence spotter which can be used for remote detection of PNAs in chemical spills and leaks. This instrument works on the principle that PNAs and other organics fluoresce (give off photons of visible light) after being excited by ultraviolet (UV) light. The hand-held device, about the size of a commercial home movie camera, consists of a UV transmitter and fluorescence receiver. The transmitter produces 1-msec pulses of amplitude-modulated UV light, which induces PNAs in the sample to fluoresce in the blue-green spectrum. The photons, emitted in corresponding 1-msec pulses, are picked up by the fluorescence receiver, which converts them to an electrical signal. Although background room light is 100 times stronger than the weak fluorescence signals, these signals may be separated out by electronic filtering because their frequency range differs from that of the background light. Greater sensitivity in determining the extent of the spill may be achieved in a darkened area.

A prototype spotter has been found to be sensitive to 1 μg of perylene (a PNA) at a distance of 1 m from the sample with the room lights on. With the lights off, the spotter is sensitive to nanogram amounts at the same distance. Besides its high sensitivity and its ability to operate in both illuminated and darkened areas, the spotter can make semiquantitative measurements (order of magnitude, or ballpark estimates) of spilled material at distances up to 2 m. Tests of the prototype indicate that it also can detect some heavy metals, such as beryllium and uranyl nitrate (a reprocessing waste). Schuresko says that the device has potential for detecting oil leaks if the oil is spiked with organics that fluoresce easily.

The prototype spotter will be tested this year at the ORNL hydrocarbonization plant in Building 2528. An advanced version under development (dimensions: 25 × 12 × 5 cm) will be tested at several DOE coal-conversion test facilities. Aiding Schuresko with this development were Guy Jones of the Chemical Technology Division, Bill Walker of the Plant and Equipment Division, and R. G. Phillips, formerly with the Instrumentation and Controls Division.—*CK*



In this conceptual design for in situ coal gasification, steam and oxygen are injected into one set of wells while raw gas is drawn out through the next set of wells. Simultaneously, a link is formed to the high-pressure air-injection wells by reverse combustion. Raw gas is piped to the main plant for ultimate synthesis of gasoline.

Gasoline from Underground Coal

There are vast underground coal deposits in the West that are virtually untouchable. To reach the coal in seams deeper than 300 feet would require deep-pit mining followed by land reclamation, the cost of which would be too prohibitive to consider. One way to effectively use this coal is to burn it in place, to recover the raw gas from the partial combustion, and to process the gas into fuels with high energy content. The Department of Energy is now trying to determine if in situ gasification of coal to make products such as gasoline is technically and economically feasible.

Seeking input for its decision, DOE has funded trial runs conducted by the Laramie Energy Technology Center and Lawrence Livermore Laboratory in gasifying small subsurface coal deposits in Wyoming. Recently, ORNL provided DOE with an economic evaluation of an in situ coal gasification facility for producing gasoline. Previously, ORNL had calculated the price of other potential products from underground coal gasification—namely, substitute natural gas, synthetic gas, and electricity.

In the latest study, ORNL has developed a process design for making gasoline from underground coal and has determined the costs of doing so in order to calculate the price of the gasoline before distribution to retailers. The conceptual in situ process design involves injecting steam and oxygen into the coal via steel-pipe injection wells that penetrate seams 300 feet deep, combusting the coal with a substoichiometric amount of oxygen to achieve partial combustion, and piping the raw gas removed from the seam to the main plant where it is converted to gasoline. In this plant, the raw gas is scrubbed, compressed, and converted into methanol, which is dehydrated into dimethyl ether and reacted using a process developed by the Mobil Corporation. A product consisting of dozens of different hydrocarbons is yielded.

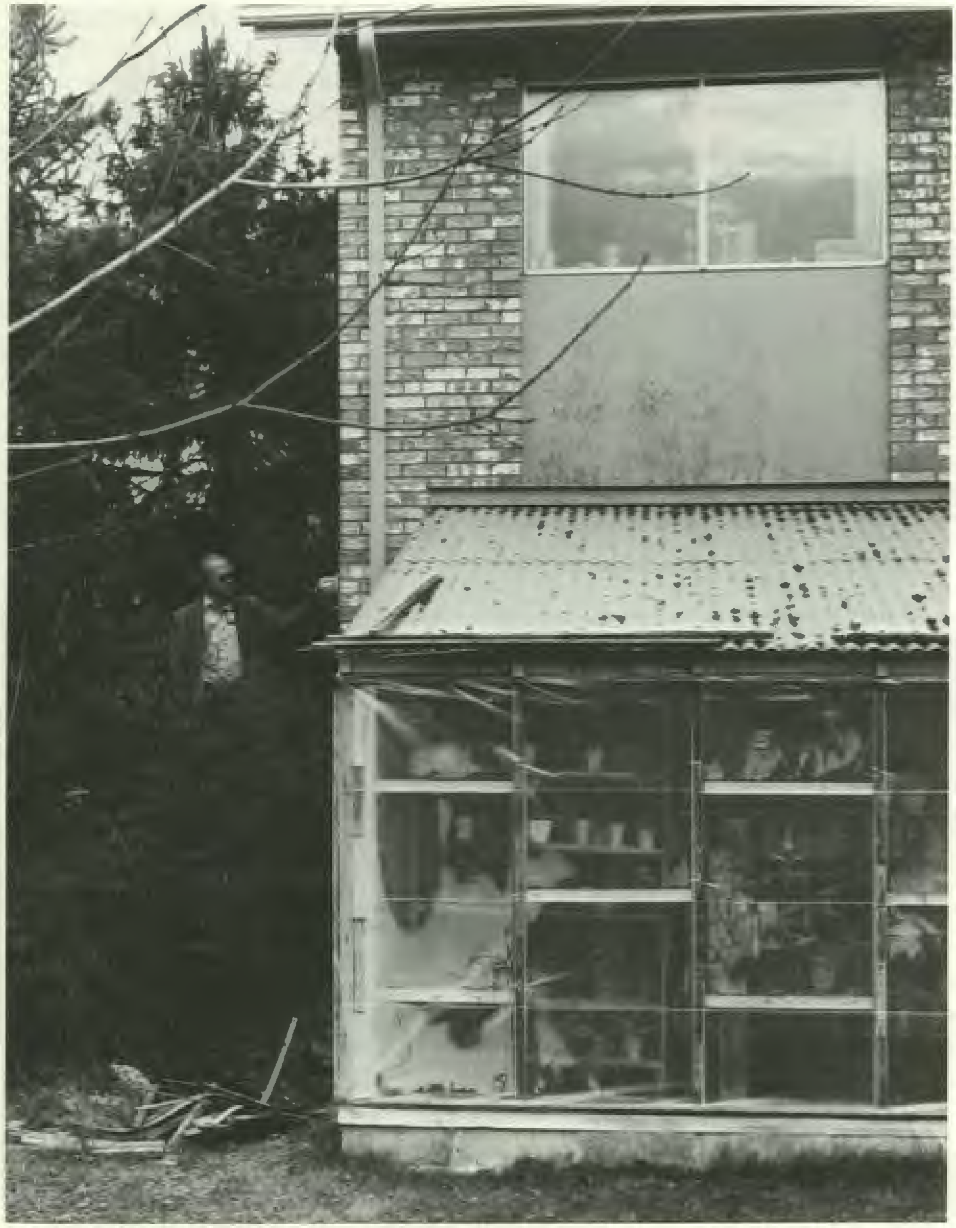
For making gasoline, the hydrocarbons heavier than butane are used and the lighter hydrocarbons (normal and iso-propanes, butanes, and butenes suitable for blending in gasoline) are reacted in an alkylation plant to form heavier hydrocarbons. Besides gasoline, this process produces propane and butane LPG (liquid petroleum gas), heating fuels which may also be sold to help cover plant costs.

In their economic evaluation, Mike Edwards, W. C. Ulrich, and Royes Salmon prepared a conceptual process design and cost estimate for a facility producing about 15,000 barrels/day of gasoline using subbituminous Wyoming coal at a consumption rate of 20,000 tons/day. The capital investment was estimated to be $535 million in 1978 dollars.

Using a debt to equity ratio of 70:30, an interest rate on a debt of 9%, an after-tax earning rate on an equity of 15%, an in-place coal cost of $5/ton, an LPG by-product credit of $4/million Btu, and a plant factor of 90%, the ORNL team calculated the product price of gasoline at the plant gate to be about 90¢ per gallon. By comparison, the price of currently marketed gasoline at the plant gate is about 43¢ before the addition of marketing and distribution costs, retailers' profit margin, and taxes.

The 90¢ figure for the base case varies slightly in sensitivity analyses in which certain economic assumptions are changed. Such assumptions might include eliminating tax losses credited to a parent corporation, removing the 10% investment tax credit, altering the assumed plant reliability, and increasing the price for the LPG product.

Edwards says that gasoline from underground coal could be a useful supplement to present supplies even though it might cost twice as much until serious oil shortages arise. DOE must decide whether these and other economic results are sufficiently promising to justify greater effort and expenditures of research funds in proving the technical feasibility of in situ gasification.—*CK*



Dick Raridon's first work at the Laboratory was in 1954 under an AEC Radiological Physics Fellowship, which led to a master's degree in physics at Vanderbilt. He conducted his thesis work at ORNL also, earning his doctorate in chemistry also from Vanderbilt. After several years of teaching at Memphis State University, he joined the Water Research Program in 1962, transferring to the Computer Sciences Division in 1972, where he has since worked on computer modeling of trace elements in environmental pathways. Recently, he has taken increased interest in energy conservation, delivering a talk on this subject to the Tennessee Academy of Science in November. The following is an adaptation of his talk. He is shown here checking the meter on his house in Oak Ridge, with his greenhouse in the foreground.

Watching the Slopes

Winters in Oak Ridge

By DICK RARIDON

For anyone who has added insulation or storm windows to his home recently, costs of heating and cooling should be less in the future than if he had not done anything. But how much less? That's a question that depends on a number of factors, not the least of which is the unit cost of energy. You can't simply compare the price you may pay to heat your home next January with what you paid last January. You can't even compare how much energy (kilowatt-hours, for example) you used for the two months. You also have to take into consideration how cold it was during the two months in question.

Coldness is measured in degree-days. The number of degree-days for a given month or a given season

Table 1. Degree-Days of Heating (Based on 68°F) for the Oak Ridge Area

Year	January	February	March	April	May	June	July	August	September	October	November	December
1951	860	683	593	384	128	0	0	0	38	235	782	809
1952	727	690	623	274	75	0	0	1	44	428	687	860
1953	743	697	532	368	38	0	0	0	46	211	648	930
1954	888	608	625	158[a]	254[a]	20	0	0	17	302	689	933
1955	948	728	553	215	41	52	0	0	1[a]	340	700	921
1956	1016	585	543	326	52	40	0	0	52	136[a]	583	520[a]
1957	816	522[a]	584	232	62	0	0	0	31	339	519	766
1958	994	981	710	312	80	1	0	0	47	281	534	968
1959	987	695	718	281	48	4	0	0	2	213	613	820
1960	857	884	988[a]	278	192	0	0	0	22	227	618	1023
1961	1069	597	493	429[a]	175	24	5	0	40	318	512	848
1962	984	620	676	422	34[a]	2	1	0	96	238	652	1038
1963	1135	989	477	270	118	3	4	1	42	179	598	1157[a]
1964	958	942	630	226	73	9	0	17[a]	55	396	495[a]	808
1965	908	808	703	230	34[a]	13	0	4	36	362	550	819
1966	1077	786	587	331	132	21	0	0	47	381	601	913
1967	847	881	464	205	194	19	11[a]	3	113	319	706	731
1968	963	1017	589	295	124	0	0	2	39	292	613	971
1969	995	815	821	255	71	16	0	0	61	304	692	969
1970	1181	835	643	246	84	12	0	0	31	208	626	782
1971	963	801	726	311	147	0	0	0	5	141	635	619
1972	841	879	661	311	127	29	6	0	13	329	624	735
1973	941	829	395[a]	379	193	0	0	0	20	196	505	882
1974	641[a]	735	439	301	110	60[a]	0	0	110	421	658	874
1975	829	694	722	393	58	7	0	0	126[a]	285	580	879
1976	1093	643	552	343	227	17	8	0	99	482[a]	842[a]	1029
1977	1335[a]	872	527	255	92	41	0	1	28	442	534	983
1978	1254	1030[a]	670	319	165	9	1					
Average	955	777	616	298	112	14	1	1	47	296	622	874

[a]Extremes

The number of degrees between a given standard temperature (in this case, 68°F) and the average temperature in a 24-h period is called a degree-day. The total heating degree-days for each month in Oak Ridge from 1951 to the middle of last summer have been calculated here. If you have your old heating bills, you might like to construct your own slopes.

is often quoted on the weather news or in the newspaper. It is calculated on a daily basis by taking the difference between the average temperature for that day and some reference temperature. The weather service uses a reference temperature of 65°F. Thus, if the average temperature for a given day is 55°F, there is a difference of 10 degrees for one day, or (10 × 1) 10 degree-days. Obviously, if you want to maintain a temperature of 65°F inside your home, it will take more energy if the outside temperature averages 45°F than if it averages 55°F. It won't necessarily take twice as much, however, since other factors, such as the amount of sunshine, enter in. If you have an all-electric home, as we do, you also need to take into consideration the amount of electricity used for such functions as lighting, cooking, and heating water. If you maintain a temperature of 68°F or higher in your home, that also has to be taken into account. That is to say, you have to know the degree-days for your home, not simply what is given by the weather service. For example, the coldest month in the history of Oak Ridge was January 1977 with 1242 degree-days, with an average daily temperature of 24°F. If you wanted to convert that to a value based on 68°F rather than 65°F, you would simply add 93, which is the product of 31 days times a temperature difference of 3°. Thus, January 1977 had 1335 degree-days based on 68°F.

There are also degree-days of cooling during the summer. In this case, 75°F is taken as the reference temperature. An average daily temperature of 85°F would mean 10 degree days of cooling per day. Any daily average temperature between 65 and 75°F results in 0 degree-days, as calculated by the weather service. Since monthly totals of

Table 2. Degree-Days of Cooling (Based on 75°F) for the Oak Ridge Area

Year	May	June	July	August	September
1960	5	20	67	90	29
1961	1	16	46	41	44
1962	21	7	62	65	20
1963	5	28	37	53	5
1964	2	78	53	47	12
1965	1	1	46	69	18
1966	0	26	130	49	6
1967	0	35	7	14	0
1968	0	31	95	164	1
1969	1	51	124	17	11
1970	2	16	86	80	52
1971	0	41	39	48	21
1972	0	7	59	45	8
1973	0	18	72	47	35
1974	0	9	36	22	1
1975	7	9	29	58	9
1976	0	5	42	17	0
1977	0	30	98	45	14
1978	0	26	63		

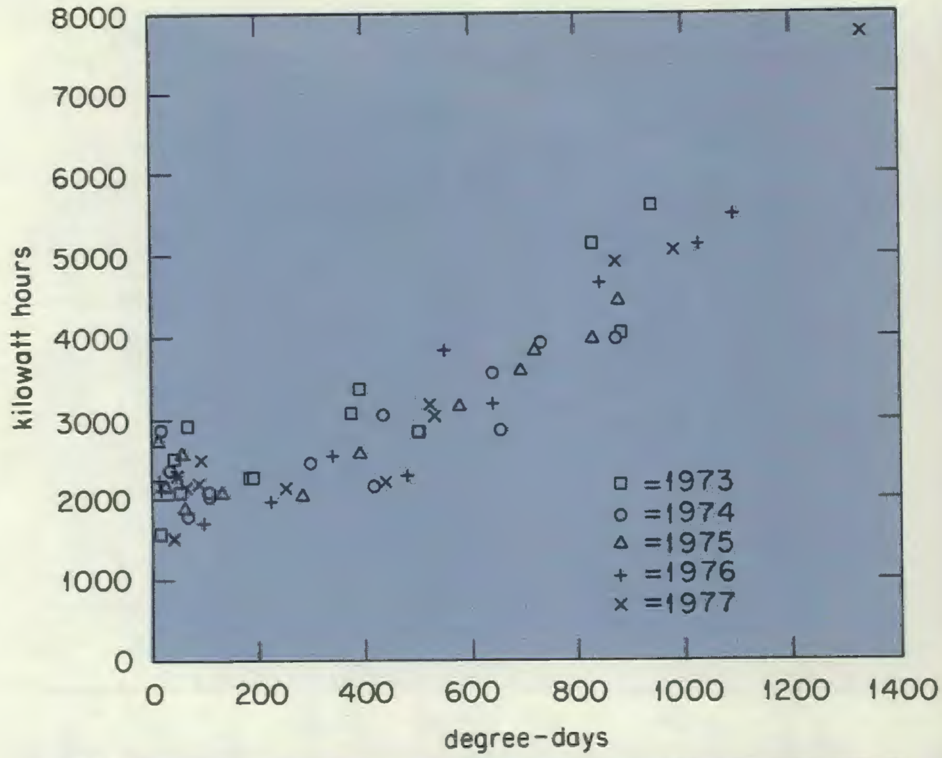
For those who want to evaluate their air conditioners, here are the cooling degree-days since 1960.

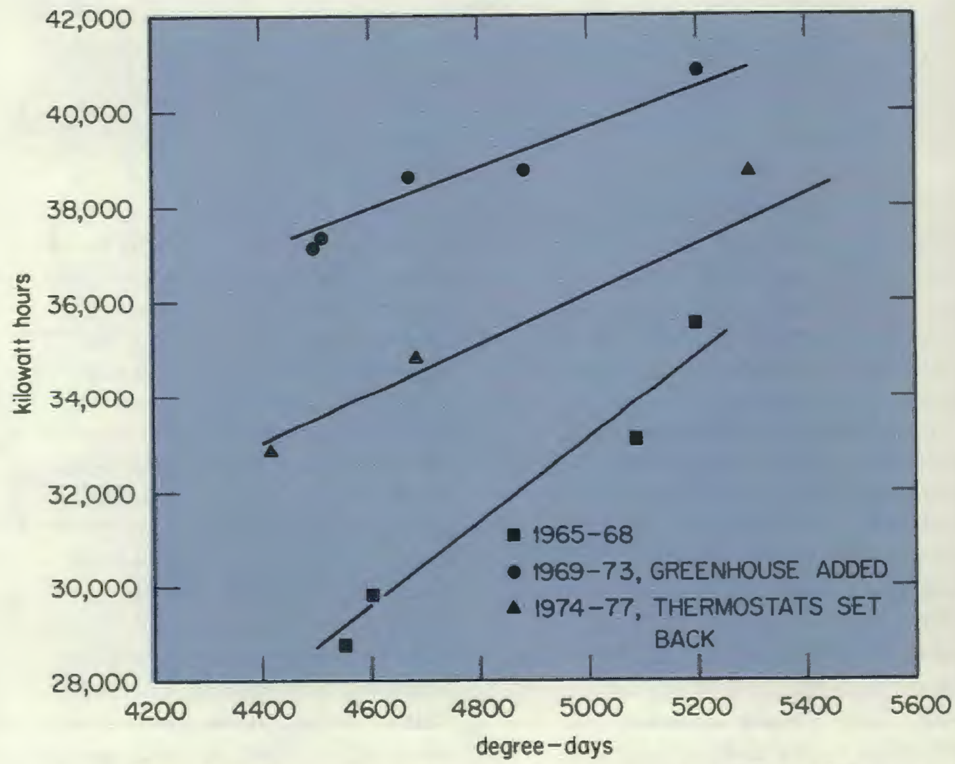
cooling degree-days are small (50 to 150) compared with heating degree-days (an average of 955 for January), it would be difficult to estimate savings for summer months.

I decided about a year ago to install additional insulation on our home, but it was January before I could find any for sale. At least it wasn't too hot working up in the attic then! I had recorded the amount we had paid for electricity since our home was built 14 years ago, but I didn't begin to record the kilowatt-hours used until about 5 years ago. With the help of Don Cipriano in the Oak Ridge City Utility Office, I obtained the rates used earlier and was able to reconstruct our electrical usage. Unfortunately, the meter wasn't always read on the first of the month, so I had to redistribute the usage on a monthly basis. In this way, I arrived at the amount of electricity we used for 1965 to the present time. We have a two-level, ranch-style house with 3200 ft^2 of floor space, all heated (and cooled) by a heat pump. Since our heat pump is an older model, it is not as efficient at temperatures below 30°F as some newer models, and it cuts off completely at 24°F, switching over to resistance heating. (Since 1968, I have also been keeping a 260-ft^2 greenhouse at 55°F during the winter, heated with resistance heating.)

Through the office of Searle Swisher of the Atmospheric Turbulence and Diffusion Laboratory, I obtained climatological data for Oak Ridge from 1951 to the present. I found summaries of heating degree-days and converted these to a reference temperature of 68°F, although we used to keep our thermostat closer to 72°F. These statistics are shown in Tables 1 and 2. As you can see, there is considerable variation for a given month. The low for December was 520 degree-days in 1956, while the high was 1157 in 1963. The averages for this time period are listed at the bottom. I have the original data based on 65°F if anyone is interested in it. Table 2 lists the degree-days for cooling from 1960 to the present. I combined these values to get the total degree days. I then plotted a graph of kilowatt-hours vs degree-days. Figure 1 shows this for the period 1973–1977 on a monthly basis. As you

A comparison of the last five winters in terms of electricity use is in the top graph, while below, the slope angle is the critical feature; it shows how significantly the addition of insulation reduces the increase in power consumption.





can see, there is a certain baseline amount of electricity used, even when the number of degree-days is low. Approximately 2000 kWh per month is used for such purposes as lighting and cooking. Beyond about 400 degree-days, there is a roughly linear relationship as might be expected. Some of the scatter can be accounted for by absences such as vacations. I also plotted yearly totals of kilowatt-hours and degree-days for the period 1965–77. In Figure 2, you can see that adding a greenhouse increased our annual electrical usage about 7000 kWh above what we had used during 1965–68. Starting in 1974, with the energy crisis, I cut the thermostats back in the house, greenhouse, and water heater. We also made a conscious effort to use fewer lights. As a result, our annual usage dropped about 4000 kWh. I expect that I will see an additional drop due to added insulation when I plot similar data for the next four years. At least the slope of the straight line should decrease.

It is interesting, and somewhat sobering, to see how the price of electricity has changed in the past 14 years, by about a factor of 4. Our total electric bill for 1965 was $220. Recently we had a bill for $180 for one month. Even if you heat with gas or oil, you have had price increases. For either of these fuels, you can plot similar curves to the ones for electricity usage. Simply substitute cubic feet of gas or gallons of oil for kilowatt-hours. Let's all work to lower our slopes!

awards and appointments

Caius V. Dodd was selected to serve on the Board of Directors' Awards Committee of the American Society for Nondestructive Testing. The committee selects winners of the prestigious ASTN Gold Medal and the Achievement and Tutorial Awards.

Robert W. Hendricks was appointed to the Membership Committee of the Division of High-Polymer Physics, American Physical Society, for a term of three years. He was also elected to membership on the Commission on Crystallographic Apparatus of the International Union of Crystallography for a three-year term.

Robert W. McClung was invited to serve as a member of the Advisory Board for the newly established Nondestructive Evaluation Division of The University of Tennessee. He has also been elected to Honorary Membership in the American Society for Testing and Materials' Committee E-7 on Nondestructive Testing. In the 40-year history of this committee, less than ten people have been selected for this honor. Selected for Honorary Membership in Committee E-10 of the Society is **Raymond G. Berggren.**

Vinod K. Sikka, Stanislav A. David, Elmer H. Lee, C. W. Houck, and **Barbara L. Booker** received first place awards in the Optical Microscopy–Ferrous Class of the 1978 International Metallographic Exhibit, held in conjunction with the annual meeting of the International Metallographic Society in Montreal. Their exhibit is entitled "Strain Burst Phenomenon in Creep Deformation of Type 316 Stainless-Steel Casting." At this meeting, **Carus K. DuBose** was appointed Editor of *International Metallographic Exhibit,* a publication of the Society.

James A. Horak was elected Chairman of the Materials Science and Technology Division of the American Nuclear Society for 1978–79. **James L. Scott** was reappointed Chairman of the National Program Committee of the Society, and **James F. King** and **Ronald L. Klueh** received an American Nuclear Society award for the best booth display during the Materials Science and Technology Division's poster session at the Society's winter meeting in Washington.

R. J. M. Fry has been appointed to a four-year term on the U.S. National Committee on Photobiology of the Assembly of Life Sciences, National Research Council, National Academy of Sciences.

Stanley Leibo has been elected Vice-President of the Society for Cryobiology. His term began January 1.

John S. Cook has been chosen President-elect of the Society of General Physiologists.

H. F. Dunlap has been named a Fellow of the Instrument Society of America.

F. C. Hartman has been selected to be the 1979 recipient of the Pfizer Award.

Kimiko O. Bowman has received the Outstanding Alumnus Award of 1978 from Radford College in Virginia. She was elected an Ordinary Member of the International Statisical Institute.

Chuck Coutant has been named Fellow of the American Institute of Fishery Research Biologists.

D. Billen will serve as Editor-in-Chief of *Radiation Research* beginning in July.

D. E. Olins has received the von Humboldt Senior Scientist Award from Germany. He will spend 16 months, beginning next August, at the Institute for Experimental Pathology in Heidelberg.

Peter Mazur has been appointed to the Subcommittee on Biology and Medicine, Advisory Committee on Polar Programs, National Science Foundation.

Victor J. Tennery was appointed to the Public Relations Committee of the American Ceramic Society.

Richard J. Beaver qualified as an ASQC Certified Quality Engineer by passing a written examination of the American Society for Quality Control.

William O. Harms has been named director of the Laboratory's Nuclear Technology Programs. Succeeding him as director of the Breeder Reactor Program is **Peter Patriarca.**

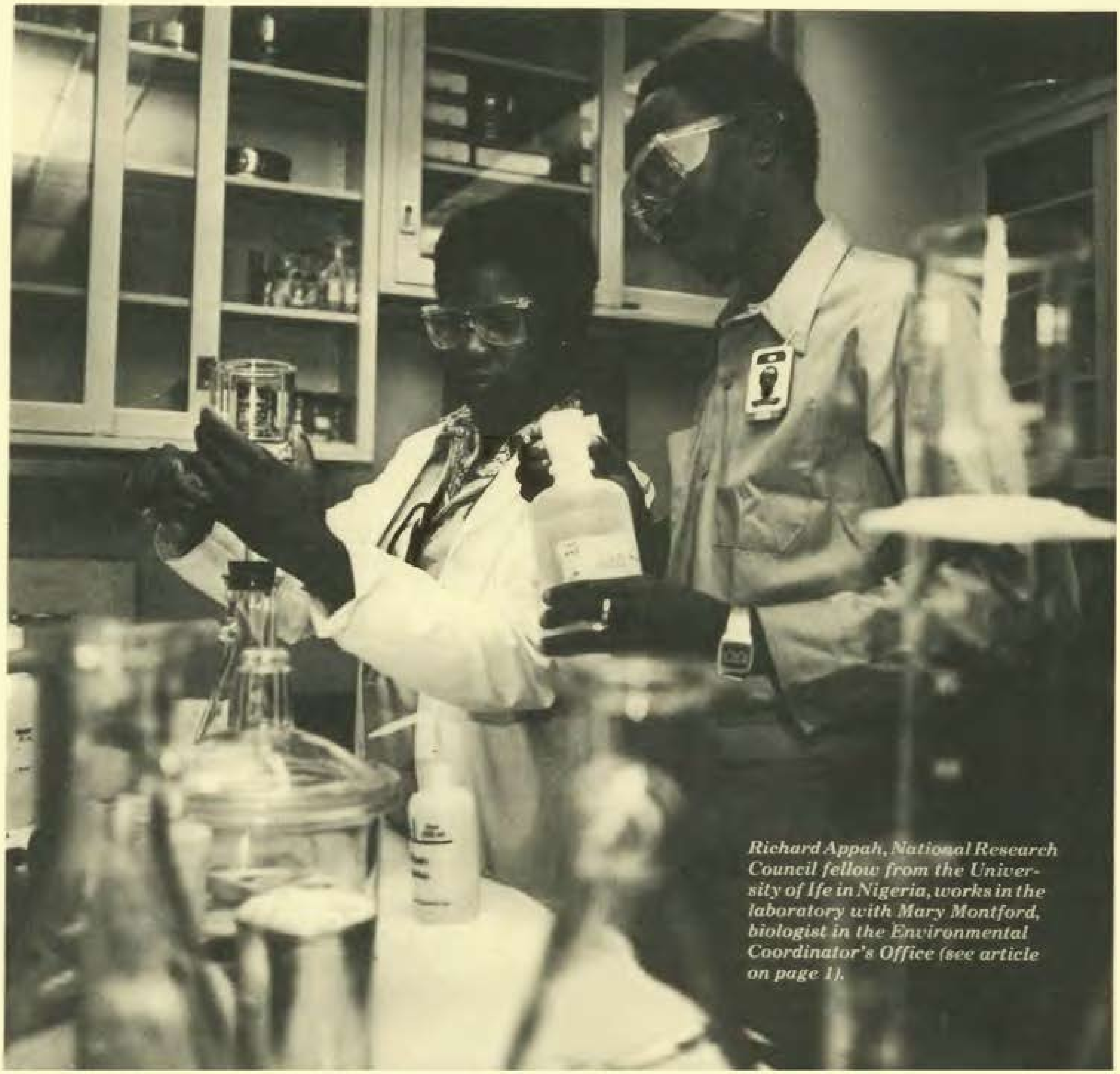
Director of the newly formed Energy Conservation Program is **Roger S. Carlsmith.**

Dorothy M. Skinner has been named associate editor of *Growth,* a journal devoted to the problems of normal and abnormal growth.

Clifford A. Burchsted has received the American Society for Testing and Materials Award for Appreciation for his outstanding service to the Society.

OAK RIDGE NATIONAL LABORATORY ***REVIEW***

P. O. BOX X: OAK RIDGE, TENNESSEE 37830



Richard Appah, National Research Council fellow from the University of Ife in Nigeria, works in the laboratory with Mary Montford, biologist in the Environmental Coordinator's Office (see article on page 1).