VOLUME 10 NUMBER 2

REVIEW

OAK RIDGE NATIONAL LABORATORY · SPRING 77

State of the Laboratory—1976
"Work with Others"

THE COVER: The companies and institutions whose symbols and seals make up the design of the cover are a few of the "others" with whom the Laboratory has interacted in 1976, giving Director Herman Postma his theme for the recent State of the Laboratory address. To find out the nature of ORNL's work with others, read the text of the address, which begins on page 1.

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REVIEW

VOLUME 10, NUMBER 2 SPRING 1977

FEATURES

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION • FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

State of the Laboratory—1976

Work with Others

By HERMAN POSTMA

IT IS ONCE AGAIN a real privilege to discuss the State of the Laboratory, particularly as it was during the year of the Bicentennial.

To help celebrate that event, we enlarged the *Review* for its Fall Bicentennial issue, one that evokes the rich heritage of the Laboratory. In addition, we offered the Bicentennial lecture series to stir our thoughts on the role of science in our society and on our special obligations.

But what I say here will only relate to the Bicentennial as it pertains to accomplishment and excitement of purpose.

ORNL has many characteristics as an institution. It has often been seen as a multiprogram laboratory. At present, it has 5 major ERDA programs, plus 21 others to various degrees—almost the full complement of programs within ERDA. But these programs are not separate; once inside the Laboratory, they relate to each other, so that what influences the course and direction of scientific findings in one program carries over to others.

ORNL has also been characterized, and perhaps most often, as a multidiscipline institution. From the Laboratory's inception, the broad mixture of disciplines has served to solve complex problems so often that it has become a way of life to us. Perhaps less appreciated are the ways in which ORNL has helped to create subdisciplines of the traditional ones or to use them in innovative ways. An example is the way plasma physics in the Fusion Program has grown quickly from an almost nonexistent field to one with a great scientific foundation. To name others, we have helped to create nuclear chemistry, ecosystem analysis, and radiation biology; more recently we have nurtured the rise of the information discipline. We have also seen disciplines evolve in new ways. In only a few years, many of the social sciences have been brought to ORNL.

The Laboratory can simply be described as a national laboratory working on national problems. Many will remember the difficulty (and acceptability) in working for other Federal agencies back in the early sixties. In fact, Section 33 of the Atomic Energy Act was eventually amended to permit us to work for other agencies. Other labs followed, and now we are very comfortable (as is ERDA) with that situation, taking for granted our "work for others" and the more than $35 million a year that we receive from 11 agencies. ORNL has demonstrated that the laboratories can diversify and perform well several interrelated missions. The legislation leading to the formation of ERDA has been seen by some to be a direct result of the national laboratories' proven ability to integrate and draw together those components which now make up ERDA.

Another characteristic—continuity—has become more appreciated lately. As agencies rise and fall, or become renamed, or are reorganized within; or as people shuffle from one place to another or change jobs in short time spans, the work is still getting done—by the labs. This characteristic results in valuable continuity to research, continuity of purpose, and continuity of staff with the dedication to accomplish vital tasks.

Those characteristics—multiprogram, multidiscipline, truly a national laboratory, and continuity—are all important qualities.

Now, I want to add another characteristic, for it indicates an important and growing involvement for the Laboratory. Let me call it, for short, "work *with* others," as a companion to "work *for* others." Though not a new involvement, it is a growing one and may, in the long run, be one of the most important.

One of the primary stated intents of ERDA is to ensure that the fruits of its R&D enter the market place, the real world, as soon as possible. Simply put, our R&D should either save energy or supply energy that can replace foreign oil.

Put into practice, this means maximum utilization of the complex institutional arrangements of the U.S. interactions with universities, industries, the commercial world, state and local governments, energy research centers, and other national laboratories.

During 1976 we saw ERDA take bold actions such as proposing a Synthetic Fuels Act, a Nuclear Fuels Assurance Act, and an Energy Extension Service. These measures portrayed on a grand scale the intent of ERDA to create new interfaces and to make sure that the R&D was indeed translated. But all of those attempts have so far failed.

On a smaller scale, quietly but surely the staff of ORNL had been working toward those very goals, not only in 1976 but for some time. I propose to list some examples to dramatize the practice that has been under way at the Laboratory in "work with others."

General Modes of Interaction

There are, of course, many ways to describe the relationships between Oak Ridge and the variety of institutions with whom we interact. They fall into several broad categories: ORNL and industrial activities, ORNL and universities, ORNL and other laboratories, etc. Then, after the broad categorization, I will cite cases within the areas of basic energy sciences, life sciences, social sciences, fusion, fission, coal programs, and conservation to highlight those relationships. Let me first describe some general categories.

One common interaction of ORNL and industry is our procurement of specialized equipment, supplies and material, services, etc. During the past year the Laboratory spent $40 million on such activities. This, of course, provides industry with one means to develop a market, but that is not the chief interaction with industry I wish to stress. Rather, it is another common interaction—our use of the R&D expertise in industry. Some work at ORNL is carried out through R&D subcontracts in specialized areas within industry. Industry has the experience and personnel to provide the needed R&D work to extend our own. During this past year we have spent $4 million subcontracting R&D with industry in this way. We are also strongly involved in jointly funded R&D. Together we work on large technological tasks in which our role may be chiefly in the developmental stage and industry's may be in the implementation stage. Several such relationships exist, the largest of which is our work with General Atomic Company in the Gas-Cooled Reactor Program. There is always the transfer of technical and scientific information to industry by means of direct communications, conferences, special meetings, or scientific information channels. We also choose advisors from industry; many of the people who sit on our divisional advisory committees or are called in to render special overviews have come from industry. Laboratory capabilities are even contracted for occasionally by industry in those areas in which we have unique facilities or services.

Another important interaction is with universities. Some of it takes advantage of academic R&D expertise by subcontracting research programs at universities. We spent approximately $3 million in 1976 doing that. We also frequently undertake joint projects with special consultants from universities. Many academic visitors use our facilities at the Laboratory and reciprocate the favor at their institutions. We have student research assistants and work with special schools such as MIT Practice School, Great Lakes Colleges Association, and Southern College University Union. We now have formalized users groups in which universities are strong participants, and consortia such as ORAU are involved with us.

ORNL cooperates with other laboratories—its sister laboratories in ERDA as well as other federal laboratories—in joint projects. Sometimes we might be the lead laboratory providing the scientific overview and distribution of funds; at other times we are recipients. An example I'll mention later is our cooperation with the Savannah River Laboratory.

ORNL has maintained a number of interactions with state and local governments; many were mentioned last year and have continued.

ORNL has a specific program for the transfer of technology and commercialization. This program calls attention to Laboratory accomplishments that we think to be of interest to industry. We then make arrangements for interested representatives to visit and view the work, explaining the process or findings in detail, and may even support them as they extend the work on their own.

One of the chief interactions is achieved by the professional staff through private contacts, professional societies, professional groups, and committees on which they serve.

As yet another example, over 25,000 visitors came to the Laboratory to view the work on site. Of these, 1250 were here as guests researchers. They spent an average of three months performing research with members of the staff. We have 300 guests (100 foreigners) at the Laboratory at any given time; this complements our professional staff by 15%.

Using all these modes of interactions and probably several more that I have not mentioned, I will come to my basic theme, the recounting of the work in the various parts and programs of the Laboratory that combines to illustrate those many interrelationships of "work with others."

But, as always in choosing examples to illustrate the point, I will unfortunately but inevitably omit many equally deserving projects and programs.

Energy Conservation

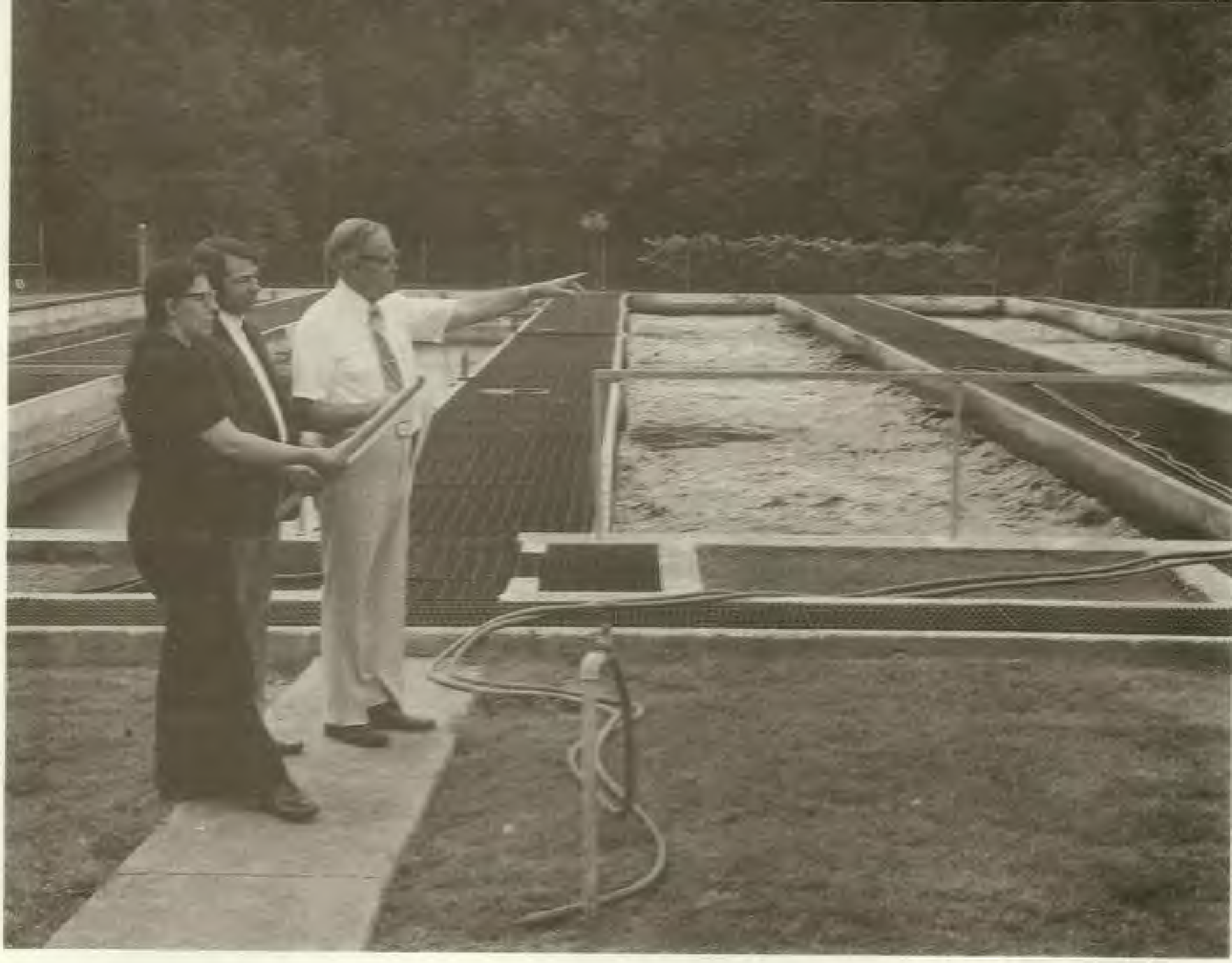
In reviewing the year's accomplishments, I mention first the area of energy conservation. ERDA's National Plan for Energy Research, Development, and Demonstration assigns high priority to development of means for making more efficient use of energy and thereby reducing future increases in demand. Our particular focus at ORNL is on residential energy conservation, a sector that accounts for approximately 20% of the nation's overall energy consumption. But first let me cite two or three conservation developments from outside the residential area, both because they represent significant contributions by ORNL people and programs and also because they illustrate important, new, and quite different types of interactions between the Laboratory and outside organizations.

Early in the year, a comprehensive assessment of industrial thermal insulations was completed by the Metals and Ceramics Division and the Energy Division and published in a report by Ralph Donnelly, Vic Tennery, Dave McElroy, Gordon Godfrey, and Jim Kolb. This work, performed at the request of ERDA's Office of Conservation, included a survey of major insulation manufacturers, energy-intensive industries, and insulation system designers. Information was obtained from more than 70 industrial and commercial sources to determine the extent and effectiveness with which thermal insulations were being applied and to provide a technical assessment of existing materials. This study identified potential energy savings from more effective use of thermal insulation amounting to about 1.5 quads (1.5×10^{15} Btu) per year for the six largest energy-consuming industries in the United States. Such savings would reduce the total process energy consumption of these industries by about 9%. They represent about 2% of our total national energy consumption. Approximately half the savings could be accomplished by increased insulation and maintenance of industrial steam distribution systems. The other half is represented by all other low- and high-temperature industrial processes. These and other results were presented and evaluated at a workshop in March attended by more than 80 participants from 50 organizations in the thermal insulation field. This relatively short-term program has resulted in national recognition of ORNL for its role in rapidly identifying an area that is crucial for improved conservation practice in industry. Recommendations from this work are being used by ERDA, the Department of Commerce, the American Society for Testing and Materials, and several trade organizations in an attempt to advance the sophistication of thermal insulation applications and to significantly improve the energy efficiency of U.S. industry.

Closer to home, we have demonstrated another important area for conservation action—one whose impact will be multiplied many times as the information is put to use by those who build and operate office buildings, schools, and other structures that are in use principally on eight-hour-a-day, five-day-a-week schedules. This is the evaluation of energy usage in our own Building 1000, done by Ernie Choat's Environmental Control Engineering group in the General Engineering Division. Building 1000 was chosen not only because it is their own office building but also because it is typical of many buildings built before the era of increased conservation consciousness that began with the 1973 oil embargo. Of Building 1000's total annual energy consumption of 2,500,000 kWhr, Ernie and his co-workers found that savings approaching 65% could be achieved through changes in lighting (which accounted for half the energy used), limiting the use of exhaust fans to regular working hours, and overnight and weekend shutdowns of heating and cooling equipment. Their general conclusion was that, in office buildings, the greatest savings can be achieved with some of the most basic conservation methods and those that involve the least discomfort to employees. These savings have been possible through the cooperation of our own employees and, particularly, the janitorial staff in turning off lights and other equipment during hours when the building is not in use. In addition to implementing these findings on a Laboratory-wide basis, Ernie and members of his staff have taken their "grass roots" conservation story on the road in recent months—to the Oak Ridge Chamber of Commerce, the Tennessee Energy Office, and various other user groups. A videotape discussion of the results of the study is also in preparation at the request of the energy office, for use on a statewide basis.

Another noteworthy conservation development is provided by our demonstration project with the Norton Company of Akron, Ohio, and the City of Oak Ridge, involving the ANFLOW liquid-waste treatment process developed by Alicia Compere and Bill Griffith of the Chemical Technology Division. This development was one of three at ORNL—more about the other two later—which this year were cited for IR-100 awards as being among the 100 most significant new technical innovations of 1976. ANFLOW reflects the strong emphasis in our bioprocess development efforts on the areas of energy production and environmental control. And it incorporates a significant conservation benefit. The process is designed to produce fuel gas or industrial chemical products from organic wastes by means of biological fermentation. High-molecular-weight organic materials are passed through a packed bed of microorganisms. The microorganisms, in turn, break down the large organic molecules contained in municipal sewage or industrial waste streams to smaller molecules which can be used as fuels or industrial chemicals. The process, being anaerobic, significantly reduces the need for energy-consuming pumps and blowers usually found in conventional activated-sludge waste-treatment systems. A 5000-gal/day pilot plant to demonstrate the scale-up characteristics of ANFLOW is now in operation at the City of Oak Ridge's East End Sewage Treatment Plant. The Norton Company has supplied the basic bioreactor hardware and packing, while ORNL has provided all of the supporting equipment and instrumentation. The site has been supplied by the City of Oak Ridge, and the city's residents, of course, provide the other important ingredient. It is expected that successful pilot-plant tests will result in ANFLOW bioreactor systems being marketed by the Norton Company and others, both for municipal and industrial applications.

The above examples have all come from outside of what I identified earlier as the Laboratory's primary thrust in the conservation area—namely, residential conservation. Last year, the development of the Annual Cycle Energy System (ACES) was described at some length. The program has



since moved rapidly from the experimental to the demonstration stage. As part of the Tennessee Energy Conservation in House (TECH) project, in which we, ERDA, the University of Tennessee, and the Tennessee Valley Authority are jointly involved, a full-scale demonstration of the ACES concept is under way in a 1500-sq-ft house on Alcoa Highway. At the end of July, this house was dedicated along with a UT house of similar design which incorporates a solar heating and cooling system. A third house with conventional heating and cooling has been built as a control. The building industry is also showing interest in ACES. In May, ground was broken in Richmond, Virginia, for the first private residence to use an ACES system. As mentioned a year ago, the Veterans Administration is planning a 60-bed nursing home in Wilmington, Delaware, that will incorporate ACES. And other cooperative projects and demonstrations are under way with the Philadelphia Gas and Electric Company and the National Home Builders Association.

Harry Fischer, the principal developer of ACES, has been responsible this year for a further refinement of the concept which may extend its

Alicia Compere and Bill Griffith, developers of the IR-100 prize-winning ANFLOW sewage treatment system, stand at Oak Ridge's East End Sewage Treatment Plant with Stan Smith of the Norton Company of Akron, Ohio. The Norton Company has provided the hardware for a pilot plant to be put in operation in Oak Ridge to test the innovative, energy-conserving bioreactor.

applications and reduce costs. This is the substitution of an ice-making unit for the refrigerated coil immersed in a large tank of water which has been used so far in the ACES installations. Ice making with this device—on daily and weekly as well as annual cycles—also appears now to be a feasible tool for load management by utilities in the areas of the country where electricity demand for air conditioning far exceeds that for heating. By making ice in the off-peak nighttime hours and then circulating the cold water for daytime cooling, the normal daytime peaks that coincide with the heaviest demand for air conditioning are avoided.

In the conservation program, we have analyzed the efficiency of end uses in studies of home heating, cooling, and hot water systems and also have performed broader analyses of regional and national patterns of energy use and the impacts of

Harry Fischer examines the new component of his ACES concept: the continuous icemaker that fills the bin below with ice chips.

conservation measures. An example of the latter is Eric Hirst's engineering-economic model for the whole residential sector. The effects of technological advances, regulatory actions, fuel prices, demographic changes, and various other factors can be investigated with the model. He and his co-workers already have made several interesting discoveries. One is that in the next two decades or so, improvements in appliance efficiencies are likely to produce greater total energy savings than improvements in building structures. This conclusion flows logically from the recognition that appliance replacements occur more frequently than new home construction, but its quantification in the model provides a basis for governmental decisions and actions. The model also indicates that the demand for energy in the residential sector will grow much less rapidly between now and the year 2000 than it has during the previous 25 years. In fact, continuation of present trends toward multifamily dwellings plus modest improvements in efficiency may lead to an overall residential energy demand in the year 2000 only 10% greater than it is in 1976. This contrasts very sharply with the situation since the early 1950s, when residential energy use doubled over a comparable 25-year span. The estimated tenfold reduction, from a growth rate of 4% a year to 0.4%, suggests that, in the residential sector, achievement of a zero-growth energy economy is well within our reach.

These examples from the conservation area all reflect a high level of interaction with outside organizations, particularly in the private commercial sector. Also worthy of mention are two other instances of significant interaction in the conservation area—our studies of the energy efficiency of gas furnaces and of mobile homes. Work with equipment manufacturers and suppliers as well as standards bodies has enabled us to achieve a very rapid transfer of research information generated within the Laboratory to the point of practical application.

Fossil Energy Development

Our fossil energy development efforts in 1976 grew into a major Laboratory program encompassing a broad spectrum of activities. The Coal Technology Program was established under Jere Nichols to provide some basic understanding about coal and to seek funds that would let us move ahead. That activity has now grown to an annual level of approximately $15 million, including funds supplied by ERDA's Fossil Energy, Biomedical and Environmental, and Physical Research Divisions. The activities range from fundamental studies of the structure of coal and investigation of the carcinogenic properties of coal conversion products to the operation of a hydrocarbonization facility for experimental studies of one of the principal coal-conversion processes and to the potassium boiler module, which represents an important approach toward improved efficiencies for coal-fired power plants. Last year, coal technology was one of the nontraditional areas of activity highlighted in the State of the Laboratory address. This year, we will not focus primarily on the programs themselves but rather on the new kinds of interactions with outside groups which they have brought about.

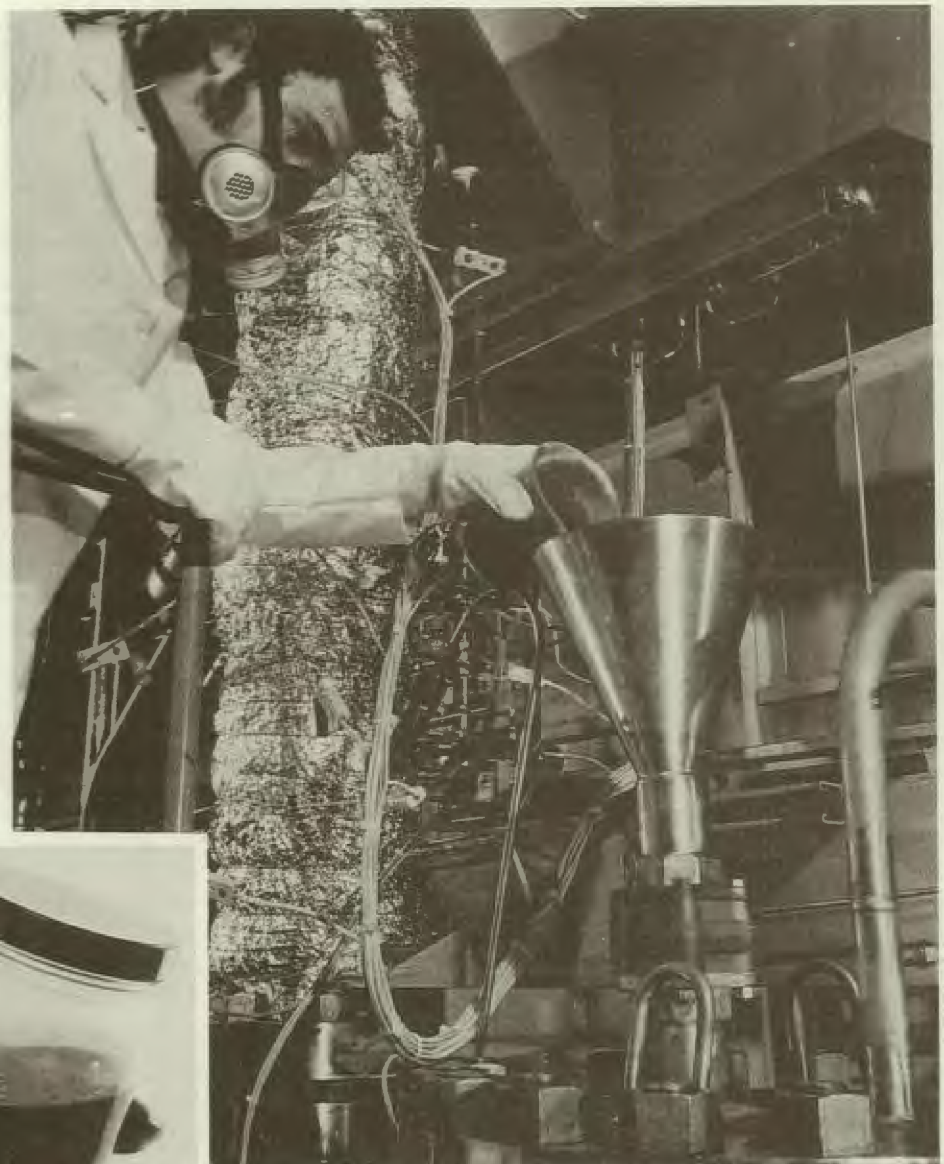
One very notable new set of relationships in the fossil energy program is with the energy research centers that came into the ERDA family from the Bureau of Mines in the Department of the Interior. As our own efforts have developed, we have been involved in an increasing number of exchanges of personnel and collaborative projects involving these centers. Many of these involve the two energy research centers closest to us geographically—Morgantown and Pittsburgh. We have a major role under ERDA, for example, in the first comprehensive engineering evaluations of two primary liquefaction processes—synthoil and hydrocarbonization. For each process, preliminary process design bases have been prepared for facilities with fuel outputs corresponding to 100,000 bbl/day of synthetic fuel oil. With the Gulf Oil Company, we are exploring applications of our solids-liquid separation work to the Solvent Refined Coal and similar processes. And with the Lawrence Livermore Laboratory, the Morgantown center, and the Laramie center, we are carrying out experiments on large-block coal pyrolysis in support of ERDA's evaluation program on in situ coal gasification.

One of our most important experimental contributions is to the hydrocarbonization process for conversion of coal to clean liquid and gaseous fuels. Since early in the year, a bench-scale hydrocarbonization facility has been in operation. This involves the chemical mixing of finely ground coal with hydrogen under elevated pressure and temperature in the reactor shown here. The process produces synthetic crude oil, a substitute natural gas, or a desulfurized char—which is a solid coke-type fuel product. This $325,000 facility processes coal at a rate of 10 lb/hr at temperatures up to 1250°F and pressures up to 350 psig. We expect later to expand the operating pressure up to 1200 psig. The objectives of this work are to determine the best combination of operating temperature and pressure for producing increased yields of synthetic fuels with sustained, economical operation. The relative amounts of oil, gas, and char produced will depend on the determination of these optimum process conditions.

Nuclear Energy

Our best-developed interactions are in the nuclear area. The existence today of the nuclear industry is a result of close exchange between the national laboratories and commercial manufacturers of reactors, systems, and components. We find that this interaction continues to be important even as the industry matures. Some examples chosen from this year's work illustrate the point.

In the Engineering Technology Division, as the former Reactor Division was renamed this year, Irv Spiewak, Otto Klepper, Truman Anderson, and others are providing the leadership for an ERDA program that is investigating the industrial substitution of nuclear and coal fuels for oil and gas in industrial processes on a large scale. They have set up an industrial marketing network consisting of reactor vendors (General Electric and Babcock & Wilcox), an architect-engineer (United Engineers), and an industrial firm (Dow Chemical Company). This combine has reached dozens of utilities and industrial users for the purpose of stimulating cooperative studies of the cogeneration of electricity and steam via coal and nuclear fuels. One group of such studies involves small industrial plants, and two studies, plus one for the Department of Defense, are under way. A large plant study is being negotiated with Gulf States Utilities as a cooperative partner. The program also contains a component of international information exchange. This program has been effective for stimulating industrial planning



In the coal hydrocarbonization laboratory, housed in Building 2528, Grady Yoder pours a feed of fine coal particles into the hopper of the machine that will convert the coal to oil. In the inset, a vial of the first "Oak Ridge crude."

for fuel substitution. It is clear that such planning will play a vital role in an orderly transition away from oil and gas fuels, on which the industrial energy economy today is so largely based. Cooperative efforts involving the energy-user community most directly affected will be necessary if we are to avoid serious dislocations in our national economy as supplies of oil and gas decline in the years ahead.

Another important area of industrial and institutional participation is the High-Temperature Gas-Cooled Reactor (HTGR) Fuel Cycle Program. In ORNL's role of developing and demonstrating equipment and processes for a viable fuel cycle, our HTGR program group interacts strongly with the program sponsors in ERDA, with the candidate reactor vendor, General Atomic Company, and with allied fuel cycle development efforts in the Federal Republic of Germany. Under Pete Lotts, ORNL is giving the leadership to the National HTGR Fuel Recycle Program, managing, guiding, and coordinating the associated technical programs carried out at ORNL, General Atomic, and Allied Chemical Company. Although the commercial future of this system remains clouded, ERDA continues to support the program because of its potential for using thorium and because of its high thermodynamic and fuel efficiencies. Two recent technological developments that involved strong participation by ORNL and cooperation with industrial participants are an improved gas distributor for fuel particle coating furnaces and determination of the optimum composition for recycle fuel. Historically, fluidized-bed coating furnaces for HTGR fuel fabrication have had conical gas distributors. A type of porous-plate distributor developed and used at ORNL has distinct advantages as regards reliability of operation and product quality. Arrangements were made to test this type of distributor in a commercial-scale coater at GA's fuel fabrication facility, and the test results confirmed its good performance. This should lead to adoption of a similar distributor for all large coaters in the vendor's facility.

Economic incentives for use of the HTGR system rely heavily on recycle of fissile uranium. Selection of a reference composition for recycled fuel involved testing many candidate compositions. All were ultimately rejected because of performance limitations except for a mixed-oxide-carbon fissile particle which is produced by loading uranium on ion-exchange resin microspheres. While the original developments on this fuel were carried out at ORNL, extensive qualification and performance testing was a cooperative venture with GA, in which we tested alternative sources of the resin and developed independent processing flowsheets, while maintaining close communication and coordination. The recommended flowsheets and compositions have now been resolved, and the processing and performance advantages of the resin-derived fuel have led to its adoption as the reference for the recycle as well as for initial makeup fuel for HTGR's, such as the second reload for Fort St. Vrain.

In our LMFBR Fuel Recycle Program, we are utilizing Bechtel Corporation experience for initial design studies of a hot pilot plant which would represent the culmination of a phased development program in the mid-1980's and are working with Gulf and Western on machine development. Our closely associated work in light water reactor reprocessing is carried out to support the Savannah River Laboratory, which has the technical lead within ERDA for demonstrating LWR recycle technology. Long-needed results on the dissolution of irradiated LWR fuel were achieved by Dave Campbell of the Chemical Technology Division. These studies of dissolution and first-cycle solvent extraction operations were initiated at the beginning of the year to resolve certain questions and to define problem areas for more extensive investigations. Problems receiving particular attention include fuel dissolution and insoluble residues, the behavior of volatile radioisotopes which enter the off-gas, plutonium extractability, stability of process solutions with respect to solids formation, characterization of insoluble materials, and waste evaporation. In order to obtain data on reactor fuels truly representative of those which a fuel reprocessing plant will have to process, most of the work has been done with fully irradiated fuel from the Carolina Power and Light Company's H. B. Robinson plant. This fuel has cooled for about two years. Seven experiments have been completed to date, each made with several hundred grams of irradiated fuel. The fuel dissolves readily in nitric acid at about 90°C, leaving an insoluble residue of molybdenum, ruthenium, and other noble metals. The residue constitutes 0.2 to 0.3% of the initial fuel but contains less than 0.01% of the actinides. Among the important results of investigations by Milt Lloyd under this program has been that plutonium extractability is surprisingly good, with "inextractable" plutonium amounting to not more than a few thousands of a percent in all cases. The work is encouraging because definitive information is being obtained on a variety of anticipated problem areas, and no chemical problems have been identified which are clearly beyond the capabilities of present technology. Such hot work is essential to the development of a viable fuel processing industry, since the irradiated materials show some significant differences in behavior compared to synthetic process solutions. The Analytical Chemistry Division has also played a major role, not only in performing many difficult analyses but also in providing hot cell facilities and personnel.

Our nuclear safety programs supported by the Nuclear Regulatory Commission represent an important part of the technical underpinning for the regulatory processes involved in licensing power reactors and are thus crucial to the industry and the utilities. One key element is the solid mechanics program under Grady Whitman, which includes our work on heavy section steel. Here the Thermal Shock Program was established to investigate the potential for flaw propagation in pressurized water reactor vessels during injection of emergency core coolant (ECC) following a loss-of-coolant accident (LOCA). R. D. Cheverton, who heads this work, reports that studies thus far have included fracture mechanics analyses of typical PWRs, the design and construction of a thermal shock test facility, determination of material properties for test specimens, and three thermal shock experiments with 6-in.-wall cylindrical test specimens. A potential for flaw propagation exists because a LOCA-ECC thermal shock would induce high tensile stresses in the inner portion of the vessel wall and because the reduced temperature and eventually fast-neutron fluence would reduce the material toughness in the same area. Calculations for the PWR indicated that under some circumstances, propagation of hypothetical preexisting flaws could be expected. Thus, an experimental verification of the methods of analysis was in order. Experiments with coolant temperatures as low as -24°C have provided tentative verification of a phenomenon referred to as warm prestressing that may limit the extent of crack propagation.

Within the nuclear area, the second of this year's IR-100 awards was received. Ed Kobisk and Tom Quinby of the Solid State Division were cited for their development of a method of fabricating ceramic wire into very accurate low-cost dosimeters for reactor applications. These are used to monitor neutron flux and energy distribution in reactor cores. Previously, their fabrication required manual loading of oxide powder into very small capsules. With the new development, a very thin oxide wire, 0.5 mm in diameter, is formed from oxide powder by an extrusion technique. The result is a reduction in the cost and human error in producing dosimeter materials. And the amount of valuable isotope needed is also reduced because there is less waste.

Fusion Energy

During 1976, two activities on which the Fusion Energy (formerly Thermonuclear) Division had been working for a number of years converged and made a significant contribution toward the development of fusion power. One is the neutral beam injector program, started by Bill Morgan and now directed by Larry Stewart, which has supplied powerful and efficient beams for use on our ORMAK experiment. Under Lee Berry's direction, the Tokamak Experimental Section has used these injectors to raise the ion temperature in the ORMAK plasma to a record 1.8 keV, or 18,000,000°C, which is about one-fourth of the way toward the required ignition temperature for a fusion reaction. In addition, for the first time in a tokamak, the ion temperature has exceeded the electron temperature, a condition that must exist in a power reactor. The results were made possible through the development of neutral beams capable of injecting 350 kW of energy into the ORMAK plasma. Largely as a result of the success of these ORMAK experiments, neutral beams have become accepted as the primary heating system for tokamaks. We are currently providing beams to be installed on the Princeton Large Torus, which began operation a year ago. And one of the major equipment developments within the division during the past year has involved the completion of the test stand that will be used in beam development for the Tokamak Fusion Test Reactor—the fusion break-even experiment scheduled for the early 1980's—on which construction is under way at Princeton. Supporting these achievements, the ORMAK physics results and their analysis by Jim Callen and his associates in the Plasma Theory Section represent a substantial contribution to the understanding of tokamak physics.

A second very noteworthy development growing out of the ORNL program this year is the concept of the flux-conserving tokamak, particularly in the light of the utility industry's negative reaction to tokamak designs that incorporated large size with low power density.

Last year, in his spare time, Division Director John Clarke began working on an idea, the flux-conserving tokamak concept, that would reduce the size of tokamaks. Aided by Dieter Sigmar of MIT (now at ORNL), Clarke calculated that the limit on plasma energy density that was previously thought to hold was invalid if one took proper account of the effect of rapid neutral beam heating. The plasma pressure in a simple tokamak might be raised by a factor of 10 over this limit. As a result, the size of fusion reactors would be reduced. Further work by Bob Dory and Martin Peng demonstrated additional properties of flux-conserving tokamaks which increase the likelihood that tokamaks will evolve into economically viable fusion reactors. For now, we believe that the flux-conserving concept is a realistic approach to high-pressure plasma operation, and it is accepted as being necessary for practical fusion power. The idea is to be tested experimentally in 1978 on the ORMAK Upgrade device, now under construction, which will have twice the plasma current and six times the injection heating power of the current ORMAK.

The momentum generated by this achievement has been considerable. In addition to the ORMAK Upgrade, a second small tokamak, the Impurities Study Experiment (ISX), is scheduled for completion during 1977. This will be a key facility for studying the behavior of impurities inside plasmas and plasma-wall interactions. The design of ISX is being carried out as a joint project between ORNL and General Atomic.

With Westinghouse, we are engaged in a design study, labeled TNS (for The Next Step), which will incorporate the concept of a flux-conserving tokamak in an experimental device designed to produce net power from fusion. This is one of two parallel laboratory-industry design efforts being supported by ERDA as it looks toward the step beyond the TFTR machine under construction at Princeton.

Within the fusion program, there are other areas of active collaboration with industry and the university community. The University of Illinois is carrying out pellet-fueling experiments on ORMAK, and the Johns Hopkins University and Rensselaer Polytechnic Institute are engaged in diagnostics work on the ELMO Bumpy Torus, the alternate fusion-reactor concept being explored in our program. We also are involved in collaborative studies with MIT on the EBT and in forced-flow superconducting magnet investigations being carried out in cooperation with the Francis Bitter National Magnet Laboratory at MIT.

Another essential element of the program for the demonstration of fusion power—superconducting magnet development—already involves a substantial volume of work under contract to industrial suppliers of large coils.

Physical Sciences

The development of new technologies and the understanding of their impacts requires a foundation of high-quality research in the physical sciences. Under ERDA, and consistent with its broader energy mission, some of our work in chemistry, analytical chemistry, physics, and solid-state physics has been reoriented toward an understanding of materials and processes important for the development of various alternative energy sources. Not all of our work in the physical sciences is, of course, directed research in the sense that it is undertaken only in support of specific development goals. It is far more often the case that fundamental work of high quality contributes in unpredictable ways to the realization of new technological opportunities.

Early in the year, an ad hoc study group consisting of Charlie Baes of Chemistry, Hal Goeller of Program Planning and Analysis, Jerry Olson of Environmental Sciences, and Ralph Rotty of ORAU's Institute for Energy Analysis was assembled by Alex Zucker and asked to prepare a report on the carbon dioxide problem—that is, the current state of knowledge, what is being done about it, and what more should ERDA and/or ORNL be doing. The report, which appeared in August, pointed out that the concentration of carbon dioxide in the atmosphere has increased steadily from the preindustrial value of about 295 ppm in 1860 to the current value of 330 ppm. Since the beginning of accurate and regular measurements in 1958, the increase has remained equivalent to about 50% of the cumulative release of fossil carbon as carbon dioxide. The remainder of the flux from the burning of fossil fuel has been balanced by the takeup of carbon dioxide in the oceans and/or the land biota. But since many of the pools and fluxes of the carbon cycle are large compared to the fossil carbon flux, it is not clear how the carbon cycle has accomplished this. Yet many of these pools and fluxes are in turn dwarfed by the economic reserves of fossil fuel (perhaps 7400×10^9 tons of carbon).

If the growth in the production of carbon dioxide from combustion of fossil fuel (typically 4% per year) continues, an appreciable fraction of this reserve could be consumed in the next 100 years, and the resulting atmospheric concentration of CO_2 could reach several times its preindustrial value. Estimates of the consequent warming ("greenhouse") effect indicate increases in the average surface temperature of the earth that range from possibly acceptable to catastrophic. Baes and his collaborators have pointed out that clearly it is necessary to foresee more accurately the consequences of the continued use of fossil fuels.

The third of this year's IR-100 awards was for work in the Metals and Ceramics Division on metal-oxide-metal eutectic composites. The investigators are Wayne Clark and Alan Chapman (now a professor of ceramic engineering at Georgia Tech and a consultant). Several years back, they discovered that a tungsten–UO_2 eutectic, solidified from tungsten metal, dissolved in molten UO_2 in the presence of a small oxygen partial pressure. Their technique of melting the inside of an oxide-metal pressed bar and translating the bar so as to directionally solidify the molten mixture has now been expanded to 39 binary and nine ternary metal-oxide-metal systems which demonstrate coupled eutectic growth. These new materials are physically composed of a high-melting-point metal-oxide matrix and very fine refractory-metal fibers. They have potential applications as high-temperature MHD electrodes, turbine components, electron-emitting guns, refractory bodies of enhanced mechanical strength and toughness, and solid-state device components.

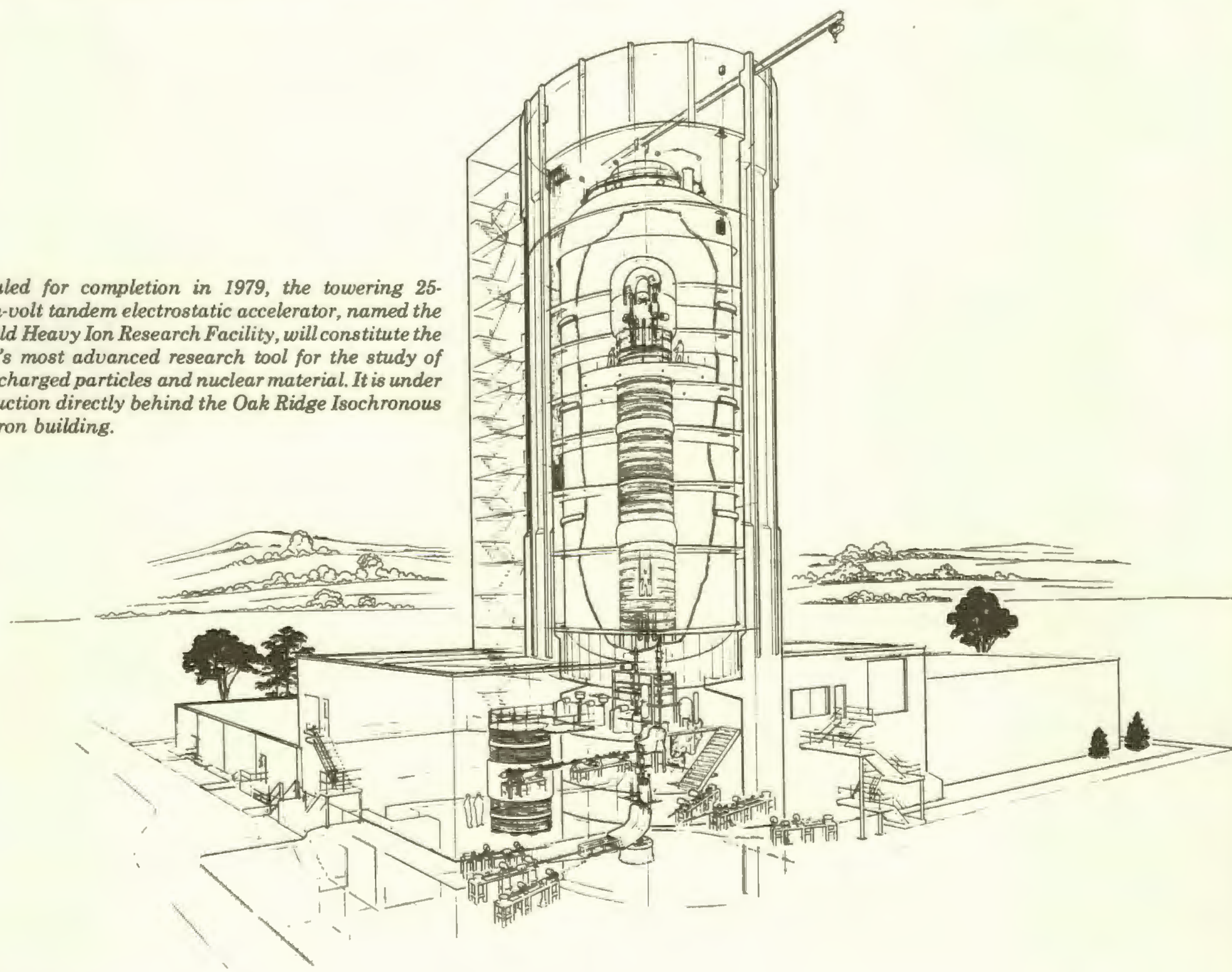
At the request of the International Atomic Energy Agency, the Analytical Chemistry Division has designed, built, tested, shipped, and placed into operation at IAEA a state-of-the-art mass spectrometer system that is to be *the* reference system for safeguards analyses for uranium and plutonium. Warner Christie, Dave Smith, and Hank McKown installed the instrument and instructed the staff there in its use. The system has met all specifications and promises to be an international showpiece.

One of the promising applications of the ORNL-developed dynamic-membrane concept of pollution control is in the pulping of wood by the kraft process. This is the subject of a cooperative program initiated by Josh Johnson of the Chemistry Division with the International Paper Company. Our participation is supported by EPA. We have shipped two small pilot units to International Paper's Moss Point, Mississippi, plant for further evaluation of the approaches. One is an ultrafiltration unit, which operates at one to a few hundred pounds per square inch on the high-volume, highly colored effluents from the bleach

Pamela Moore stands at the filtration loop at Y-12, one of two rigs now installed at International Paper Co.'s Moss Point, Miss., plant to clean up their kraft paper process wastes.

plant. The other is a hyperfiltration (or reverse osmosis) system which filters salts, as well as other low-molecular-weight dissolved material. The unit uses ceramic tube bundles, developed for commercialization of dynamic membranes by the Selas Corporation. The application for which it is primarily intended exemplifies many facets of an ideal membrane pollution-control system. It is hoped to concentrate the dilute contaminated waters from the washing of pulp enough for economical recovery of chemicals along with the spent digester liquor. By carrying out the filtration at process temperature, a clean, hot filtrate suitable for reuse is obtained, with a consequent energy saving. The cycle is thus closed, a significant step toward zero discharge.

In the early 1950s, a solvent extraction process was developed at ORNL and utilized for the recovery of uranium from the wet-process phosphoric acid produced by treatment of Florida phosphate rock. Commercial application of this process was short-lived, however, because of the discovery of large amounts of relatively low-cost uranium in the western United States and a number of troublesome problems inherent in the process. During the intervening years, the phosphate fertilizer industry has grown rapidly, and the amount of uranium dissolved in wet-process phosphoric acid has been estimated as approaching 2000 tons annually. This, together with the increasingly high market value of uranium oxide, has led to renewed interest in the wet-process acid as a source of uranium. A program is under way in the Chemistry Division to complete development of a recovery process using octylphenyl acid phosphate (OPAP) as the extractant. This reagent,



Scheduled for completion in 1979, the towering 25-million-volt tandem electrostatic accelerator, named the Holifield Heavy Ion Research Facility, will constitute the nation's most advanced research tool for the study of heavy charged particles and nuclear material. It is under construction directly behind the Oak Ridge Isochronous Cyclotron building.

In the experimental room of UNISOR, where one of the beams comes to an end, W.-D. Schmidt-Ott, l., adjusts the focal plane of the spectrograph; Ken Carter, center, works at the tape transport system; and Eugene Spajewski sits at the controls.

a commercially available mixture, demonstrated satisfactory uranium recovery in earlier bench-scale tests. Emphasis in the current tests is on separating and identifying the components of the commercial mixture and determining their role in the behavior of the extractant and on measuring its long-term stability and extraction performance. Proposals for possible joint studies with both Allied Chemical and Mobil to increase the recovery of uranium from phosphate rock are now under consideration.

Our theme of "work with others" would not be complete without reference to some other activities of this type that are current in the physical sciences areas. The 150-ft tower that will house the new Holifield Heavy Ion Research Facility's 25,000,000-V tandem electrostatic accelerator has begun to rise to the level of the surrounding buildings in the 6000 area. This, of course, will become perhaps the most important user-oriented activity at ORNL in future years. Already, a users organization numbering more than 500 scientists from the United States and abroad is actively involved in planning the experimental program and development of instrumentation for this facility, which is to be completed in 1979.

Another important user area is represented by the outstanding facilities at ORNL for neutron scattering research. These include the High Flux Isotope Reactor, which provides the most intense beam of thermal neutrons currently available. Since its inception in 1946 at the Graphite Reactor, neutron scattering has become one of the most fruitful methods of studying the structure and dynamics of solids and liquids. The 30th anniversary of that important development was celebrated in

Sam Hurst, l., Jack Young, and Munir Nayfeh scrutinize the apparatus used to detect single cesium atoms. Their development employs light from pulsed dye lasers to excite and then ionize selected populations of atoms contained in gaseous form in a counting device. Electrons freed from the laser-excited atoms trigger signals in the counter. Identifying and measuring chemical pollutants in the environment is a promising application of this sensitive detection method.

June at an ORNL-sponsored international conference in Gatlinburg. The Laboratory has long had an informal policy of cooperation with scientists from other organizations who wish to use these facilities. For example, during the past four years, more than 100 scientists from universities, industries, and other government laboratories have conducted cooperative neutron scattering projects here. Now, as part of a positive program to encourage the use of this equipment by other scientists, plans are under way to form a formal users group. Our goal is to assure maximum utilization of these facilities on problems of high scientific merit.

Finally, in this connection, I would mention the University Isotope Separator-Oak Ridge (UNISOR), which operates on-line in Building 6000 with the Oak Ridge Isochronous Cyclotron. UNISOR, a consortium of physicists from a number of Southern institutions, has produced important results this year, including three papers published in *Physical Review Letters*. One of these concerns shape isomerism in mercury-184. The list of authors and institutions is indicative of the pattern of the future when the Holifield Heavy Ion Research Facility comes on line. The masses of the stable isotopes of mercury range from 196 to 204. By use of the on-line mass separator and heavy-ion reactions with ORIC beams, the UNISOR group has been able to study the level structure of mercury-184, which is 12 mass units lighter than the lightest stable mercury isotope. Further, the level structure for this nucleus is quite unusual and indicates that, although this nucleus is spherical in the ground state, with just a little excitation energy it can be transformed into a highly deformed nucleus. Thus, we have an example of nuclear shape isomerism.

Life Sciences and Social Sciences

The life sciences represent another indispensable research component of a multidiscipline energy laboratory. This year, an exciting accomplishment, which bridges the life sciences and physical sciences, has been the demonstration by our atomic physics and laser research group of the detection of one atom. The last two State of the Laboratory addresses have followed the progress of this work. Now, Sam Hurst and Munir Nayfeh of the Health Physics Division and Jack Young of Analytical Chemistry have reported the successful detection of one atom of cesium in a sample of at least 10^{19} other atoms and molecules in a gas proportional counter. The development, representing the ultimate in analytical sensitivity, provides a completely new tool for analytical chemistry and one that can be expected to evolve into a new generation of analytical instruments. It involves pulsing laser light into the counter at such an intensity and frequency that every atom of the type to be detected, within the path of the beam, is first excited and then ionized while all others are essentially unaffected. The sensitivity of the proportional counter, through which the laser beam passes, permits a single electron, when formed anywhere within the device, to be counted. It is based on the development of a photoionization method called by Hurst "resonance ionization spectroscopy." This technique appears to be applicable over a wide range of scientific and environmental investigations limited previously by the sensitivity with which small concentrations of atomic or molecular matter can be detected. Among these applications, it is believed, will be detection of recently discovered elements produced only in quantities of a few atoms, rare events such as nuclear reactions from solar neutrinos, and the search for quarks. The authors calculate that one-atom detection can be extended to nearly half of all the presently known elements. They also are interested in such applications as the detection of daughters from radioactive decay, slow evaporation of atoms from surfaces, slow transport processes at the atomic level, and the rates of reaction of elements in various chemical environments. I should not leave this item without pointing out that it is one that has received support from our own "seed money" program as well as from ERDA's Division of Biomedical and Environmental Research, the latter as part of its program to develop improved environmental measurement technology.

The fate of plutonium in our environment is receiving increased attention in the Environmental Sciences Division. We have been working with several ERDA installations to provide information on the existing and potential hazard of the contamination. At the Nevada Test Site, Tammy Tamura is one of a team assessing the situation in the bomb test range. At Rocky Flats, Colorado, he also has been evaluating the resuspension hazard of the contamination. With the Health and Safety Laboratory of New York and Monsanto Corporation (operators of Mound Laboratory), we have been examining the bottom sediment of a canal in Miamisburg, Ohio. Our efforts have been primarily aimed at characterizing the properties of the plutonium in the soil and sediment samples from these sites and including samples from our own backyard (White Oak drainage). For example, by leaching these samples under identical conditions, the differences in the character of the plutonium can be ascertained. By comparing the concentrations found in the leaching agent with those found in the plants growing at the site, we hope to be able to predict potential uptake by vegetation in the event of an accidental release, using the leaching "quick test." Studies are also being conducted on the association of the plutonium on different mineral particle sizes. Since the hazard of plutonium by inhalation is closely associated with the size of suspended particles in the air, the results obtained are being related to the potential inhalation hazard at the different sites.

Ernie Bondietti and Roger Dahlman are evaluating, as part of the transuranics program in Environmental Sciences, the environmental chemistry of plutonium and other actinides to elucidate long-term behavior. The hypothesis is that, with respect to long-term biogeochemistry, plutonium is likely to resemble the naturally occurring element thorium. They are comparing the plant availability of uranium, thorium, and plutonium in ORNL soil contaminated with plutonium in 1944. Results with four different plant types show that uranium is assimilated about

Ernie Bondietti holds the bag for Roger Dahlman in the transuranics garden, where studies are being made to determine the long-term fate of actinides in the environment.

10 times as readily as thorium or plutonium. This information is useful in evaluating the relative radiological hazards of plutonium and the naturally occurring radioactive elements in food chains leading to man. The solubility of plutonium in water is quite low and accounts for its low tendency to concentrate in biota. A solubility model proposed by Bob Mesmer and Charlie Baes in Chemistry has been compared by Bondietti to observed concentrations of plutonium in natural waters sampled near sites of nuclear activity. Agreement between the model and observed concentrations in natural waters supports the concept that plutonium is hydrologically immobile and indicates that our predictions regarding its environmental transport are accurate.

The Environmental Sciences Division has worked with two state governments and two federal agencies investigating a large-scale fish kill in 1973 in the Cherokee Reservoir. Environmental Sciences was contacted initially by the Tennessee Fish and Game Commission to provide analyses of the fish tissue. The discovery of elevated levels of mercury in the fish muscle prompted the initiation of the NSF/RANN-sponsored "Mercury Cycling in the North Fork of the Holston River" project. The Holston River is the major tributary of the Cherokee Reservoir, and the north fork of this river drains an area near the town of Saltville, Virginia, which was once the site of a major chemical plant. The plant was closed in 1972 because of its inability to meet newly imposed federal and state water quality standards. However, in the view of Gordon Blaylock, Steve Hildebrand, Ralph Turner, and Steve Lindberg of ESD, a potentially far more serious problem existed, that of continued emission of mercury from the defunct plant's massive (110 acres) solid waste deposits. Production losses of the metal had continued for the past 20 years with the bulk of the contaminant entering the environment via the solid waste deposits.

Following publication of our initial work on the distribution of mercury in the biota, water, and sediments of the Holston River–Cherokee Reservoir system, which demonstrated the impact of the plant site on the mercury levels of various downstream components, ESD was contacted in 1975 by the Divisions of Regional Studies and Water Control Planning of TVA concerning proposed decontamination of the waste pond area.

When ORNL identified a possible source of air pollution from mercury vapor emitted from the wastes, the State of Virginia sought immediate implementation of adequate abatement measures. An interagency conference was held, with Virginia as the prime inquisitor into the technical nature of the problem and its possible solutions. Presentations by ORNL staff at this meeting revealed for the first time the quantities of mercury actually being lost to both the aquatic and atmospheric environments from the solid waste accumulated at Saltville.

Detecting mutagens in mammalian systems is difficult and has classically been achieved by examination of large numbers of progeny. In the classic case of transmission from one generation to another, only a limited number of cells are at risk for mutational events. For example, each newborn mouse represents the combination of a single egg and single sperm. The mutation must have been present in one or the other of these single cells in order to be detected in the newborn. A long-term goal in mutagenic research has been to be able to detect mutations in somatic cells, that is, in cells of the animal actually exposed to such mutagenic agents as radiation, chemicals, or other insults. The number of cells at risk is very much larger, and, while mutation rates are very difficult to establish by this method, it is nevertheless possible to test for mutagenic effects using much smaller sample sizes. In the Biology Division, a promising test for mutations in somatic cells has been developed by Lee Russell in which mice in utero are exposed to the mutagenic agent. If a mutation occurs in the cells that differentiate to produce hair pigment, then these animals, after being born and growing their fur, will show patches of odd-color hair; an otherwise black mouse, for instance, might show patches of white hair. This method has been developed to the point where it can be used to test for mutagenic effects. Its great advantage is that much smaller samples are required than are needed in more classical techniques.

The Energy Division has for a number of years been studying the effects of large energy facilities on local social and economic conditions. As part of this effort, the Social Impacts Group led by Elizabeth Peelle is investigating the effects of TVA's proposed nuclear power station on the town of Hartsville and the surrounding region. Their investigation includes the effects an influx of 5000 construction workers will have on this town of 2500 people. Social changes being considered include the problems the community will have in funding the increased cost of schools, police, roads, and other community services--problems made particularly severe because TVA plants pay no local taxes. As a consequence of the ORNL analysis and its own assessment, TVA has pledged to mitigate such impacts and to monitor the effectiveness of the mitigation strategy. In one step toward measuring the social impacts as the plant is built and operated, Peelle and her colleagues have made two surveys of the attitudes of the residents toward the plant. To our surprise, since the plant license application was hotly contested, about two-thirds of the residents were found to favor construction of the plant. This percentage agrees well with that found by the Harris survey for the United States as a whole, and it was confirmed by the votes in the seven nuclear referenda that have been held in the United States this year.

Information Centers and University Relations

One of our most important interactions is with The University of Tennessee in the UT–Oak Ridge Graduate School of Biomedical Sciences, located in the Biology Division. The school brings directly into the mainstream of full-time graduate study in the life sciences the talent and experience of the Biology Division staff as well as the most advanced research methods and technology available there. We also enjoy an active relationship through the Environmental Sciences Division with the graduate program in ecology at UT, one of the first such programs in the country, which remains one of the strongest.

In another activity, we and ORAU are participating with UT in the East Tennessee Cancer Research Center, which is designed to translate the results of biomedical research into more effective programs of cancer prevention and treatment.

Our information centers are a principal component of our work with others. In the life sciences area, a new and important information-center product has been especially significant for our developing life sciences program on synthetic fuels. Helen Braunstein, Emily Copenhaver, and Helen Pfuderer are editors of an information overview of the environmental, health, and control aspects of coal-derived materials. This recent and impressive document is already valuable to all members of the scientific community as a source of information in readily accessible form about possible pollutants from coal conversion and their health effects. It provides an interdisciplinary perspective that will be valuable in focusing our own program during its formative stages and should greatly assist researchers elsewhere in shortening the lead time required to become familiar with relevant scientific information and workers in their field.

The Information Center Complex and the centers embedded in various divisions cut across virtually all of our program areas. The operation of each represents a service to a particular outside constituency or technical area that is important to the Laboratory. From a budget and manpower standpoint, the information centers represent a significant fraction of our overall effort, accounting this year for just over $7 million of the total operating budget and more than 140 professional staff members. Their dollar return to the energy community is substantial.

While these illustrations are examples of the work that we do with others, it is difficult to find work at the Laboratory that does not have strong relationships with other institutions. For example, in the space allotted to this discussion, I could have confined myself solely to the work that has local interactions or devoted a treatise to our relationships to ORAU and IEA or to The University of Tennessee or to TVA or to the Clinch River Breeder Reactor Project. Similarly, I could have discussed the relationships of our work with that of Y-12 and K-25. But I hope the point is clear.

External Events

Again this year, nuclear energy remained under a sustained attack. Yet, during this year, an opposite trend developed, where approximately 20% of the U.S. voters voiced their concerns about the antinuclear initiatives in seven states and rejected them by a two-to-one margin.

We have seen shifts occur in programs at the Laboratory as public concern shifted. During 1976, we saw what was once a research program in Chemical Technology in waste isolation grow into an enormous demonstration program and move, as the Office of Waste Isolation, to report directly to the Union Carbide Corporation Nuclear Division president. We saw a revitalized program in nuclear fuel reprocessing come to the Laboratory to fill the immense gap left by industry during recent turbulent years. We saw reactor safety research and development continue to grow; and, of course, we've seen strong growth both in the Fusion Program and the Coal Program at the Laboratory.

We have seen our own conservation programs, particularly those in end-use conservation in residences and commercial buildings, grow strongly during this past year.

In the basic sciences we have made a number of internal shifts from nuclear to nonnuclear in anticipation of questions that are now being raised. We have even seen shifts in the writing of environmental impact statements to cover the areas of coal conversion technology and geothermal energy.

The changes that appear on the horizon for 1977 with the promise of executive and congressional reorganization will require the Laboratory to be nimble and responsive.

Internal Events

The year 1976 has been one of important technical accomplishments, and I have covered only a few of them here. It was also a year in which we saw both budgets and manpower grow in a number of important areas. I have already mentioned the growth in nuclear fuel reprocessing and nuclear safety. We have seen perhaps the strongest growth occur in the fusion programs at the Laboratory as they focus on crucial questions requiring immense technological advances. We have seen good growth in our Coal Program, not only with the technological areas but in the life sciences and to some extent the basic physical sciences. But, unfortunately, as a whole this year the basic sciences at the Laboratory received only cost-of-living increases, and what changes were made in shifting from nuclear to nonnuclear activities had to be made within restrictive budget constraints. The long-term health of the basic sciences is an important concern of ERDA, which has the responsibility for maintaining the health and the contributions of those supporting sciences.

During the past year, we saw an addition to the Laboratory of 225 people. That growth will abate as we shift toward greater interaction with and utilization of other institutions. For example, the Laboratory is becoming a lead laboratory in several areas; that is, we are becoming responsible as the chief implementer of ERDA's programs in specific areas where we are expected to maintain healthy expertise and to make sustained contributions, as well as use outside R&D expertise. Such areas include fuel reprocessing, coal conversion, life sciences, development of beams and magnets in the Fusion Program, interactions of heavy ions with matter, chemical mutagenesis, etc. In addition to assuming lead responsibilities in these areas, the Laboratory is embarking upon an extension of another role, that of actual program management. We can expect the Laboratory not only to conduct work inside its walls in many areas of technology but also to be managing programs that will utilize outside institutions. In fact, in several areas, the Laboratory will only be doing 15 to 20% of the work internally, as it assumes the responsibility for the remainder of the work being done in industry, universities, not-for-profit institutions, etc.

We have continued to formulate longer-range program plans in order to select areas where our expertise can best be applied and to convince ERDA of the necessity for a broad and concerted attack on many of the technological problems. In fact, ERDA has become responsive to such needs and is instigating its own plans for institutions such as the Oak Ridge National Laboratory in order to provide the feedback necessary for broad mission support. As a part of our long-range planning, we have been able to implement many of the features of the human resources plan. We've also become concerned about our space needs as programs grow. There is evident need to modify the Laboratory facilities as programs shift and as outmoded and dilapidated buildings go into retirement. We have similarly come up with a five-year plan to enhance the Laboratory's computing resources; an immediate result has been the upgrading of the PDP-10 for interactive computing. We have begun to look at our information sciences in a more concerted way in a report made recently, and it is being reviewed for implementation.

I am personally extremely proud of the Laboratory's health and safety results. Again this year, the Laboratory continued to improve its already excellent safety record, in its industrial safety as well as its handling of radioactive materials. There was only one lost-time accident during 1976. The industrial safety actions of all employees at the Laboratory so far have given us the best record in ORNL's history. It shows statistically that a person is 20 times as safe working at the Laboratory as in taking a day off.

A number of new programs were instigated during this year; in addition to strengthening the seed money to finance and nurture new projects suggested by the staff, we awarded four Eugene Wigner Fellowships. We began an internal sabbatical program and instigated broad in-house education courses which run the entire year to supply instruction in a number of areas in which the Laboratory is active.

Future

Comments about the future must be tempered by the near-term situation as the administration of the country changes. Perhaps ERDA will change, as massive reorganizations within the Administration and Congress in the energy area take place. The modifications of President Ford's 1978 budget by President-Elect Carter will certainly give us some clue about the policies of Mr. Carter toward energy research and development.

I believe that the Oak Ridge National Laboratory will continue to grow based upon its existing strengths. The growth of the last few years will necessarily slow down due to the lack of space and facilities, certainly not to any lack of acceptance, results, or good ideas. I believe that the basic energy sciences and life sciences will once again, perhaps in 1978, receive increased funds to be able to diversify and grow in new areas. Above all, I believe that the Oak Ridge National Laboratory will continue its superb record of timely accomplishments and contributions and scientific leadership. The traditional strengths of the Laboratory as a multiprogram institution involving many disciplines embracing topics of national importance and supplying continuity to a long-range research and development effort will broaden its characteristics of working with others to become an even stronger institution.

I am again impressed with the people and quality of accomplishments at Oak Ridge during this past year. I want to thank you for making those very great contributions. I hope the coming year can continue to be as fruitful as the past.

BOOKS

"On Systems Analysis: An essay concerning the limitations of some mathematical methods in the social, political, and biological sciences"

David Berlinski, 186 pp. the MIT Press (1976). Reviewed by Marvin A. Kastenbaum.

ARE YOU A SKEPTIC? Do you doubt that mathematical models can explain all or even part of many complex political, biological, and social systems? Then treat yourself to some instant gratification by browsing through this collection of essays by David Berlinski. This 180-page book covers three broad areas: general systems theory, dynamical systems, and mathematical systems theory. It is a book of "uncompromising negativism" whose author suggests, with delightful audacity, that systems analysis is largely a sham involving little more than an ornamental use of mathematics.

Berlinski is not a crank; he is an iconoclast whose classical training as a philosopher has obviously included mastery of many branches of mathematics. Yet he is not constrained by this competence to niggling technical criticism. On the contrary, he meditates on the limits of certain mathematical methods in the social, political, and biological sciences, and he speculates on the unsuccess of these methods. In so doing he smashes some well-known idols and scrawls graffiti over the faces of others. Following are some examples :

The applied wing of systems analysis invokes "those resuscitative arts—program budgeting, cost-benefit analysis, and the like—that systems analysts assure us bring to the operation of government a kind of sanctified effectiveness impossible to achieve under conditions of routine political piggishness."

"Equation (1.4) does have modest usefulness in the description of *uniform growth*—a continuously copulating clutch of rabbits for example.... The metric volume of confusion in this passage is nonetheless considerable."

"Isomorphisms are the third of the three pledged usufructs of GST" (general systems theory).

"For the man of fastidious mathematical sense, an analysis extruding computational detail, couched in boring boxy language, is an exercise in poor taste, like passing around samples of one's sputum."

"Both Forester and Meadows are innocents of rigor (naifs statistiques): missing from their work is some sense that a substantial body of statistical technique must mediate between an original theory and its applications."

"There are, generally speaking, two circumstances in which it is difficult to analyze mathematically a social system: the first is when the system is not linear; the second is when it is."

Fifteen years ago, at a conference on training in biomathematics, Nicolas Rashevsky said, "Atomic energy's gain was biomathematics' loss." He was referring with some pride to the fact that three of his young proteges in biomathematics at the University of Chicago in the late 1930s—Alvin Weinberg, Alston Householder, and Gale Young—were then at the Oak Ridge National Laboratory. During my own tenure at ORNL, I was privileged to work with each of these men, and in each I detected some degree of skepticism about the mathematical modeling of biological and social systems. I often wondered whether their experience with Rashevsky alerted them, early in their careers, to many of the pitfalls which Berlinski attempts to expose in his book.

At the far right, the Seaborg delegation at Petrodvorets (Peter's Palace) on the shore of the Gulf of Finland. The sumptuous grounds have been made into a vast public park. Below, the author.

USSR Nuclear

Where Seldom is Heard a Discouraging Word

By JOSEPH LEWIN

Joe Lewin, an alumnus of The Cooper Union and the U.S. Army Air Corps, joined the Laboratory staff in 1958 as a mechanical engineer in the General Engineering Division, moving in 1959 to Neutron Physics, where he served until 1975. After a brief time in the Reactor Division, he transferred to Instrumentation and Controls, where he is now. A native of Russia, he is proficient in its language, and this ability was put to extensive use by the AEC in its dealings with the U.S.S.R. very soon after he came to Oak Ridge. His adventures and experiences as a member of the USAEC delegation to the U.S.S.R. in 1971 are implicit in the delegation's report (TID-26162) entitled "May the Atom . . . ." (The title comes from a slogan, "May the atom be a worker, not a soldier," seen on a plaque at one of the Soviet installations.) His most recent trip was to the Fourth Meeting of the U.S.-U.S.S.R. Joint Committee on Peaceful Uses of Atomic Energy, held in Yerevan last December, at which ERDA Administrator Robert C. Seamans represented the United States. In the following article, Joe has lined out some of the impressions and conclusions he has derived from his contacts with Soviet administrators and scientists and their interactions with their American counterparts.

NUMBER 26 Old Coin Lane in Moscow is one place where there is no flight from nuclear power, and American visitors from USERDA are asked with incredulity whether the statements attributed to some American political figures were really made:

"Concentrate the diffuse energy of solar radiation, when nature has concentrated so much extractable energy in the uranium nucleus?"

"Double and triple coal utilization, to incur a four- or sixfold increase in environmental insult, when nuclear power is clean and still in the adolescence of its growth?"

The address of Old Coin Lane is that of the State Committee on Atomic Energy (Goskomitet po Atomnoi Energii), which is responsible to the Council of Ministers for civilian research and development of nuclear power. It has been, ever since 1959, the principal liaison agency for AEC and ERDA contacts with the Soviet nuclear community. But when those contacts began, in the late fifties, the public atmosphere for nuclear power had been very different. It was almost a weird turn of events, I thought, as I listened to ERDA officials wrestling with politicians' suggestions of actually deemphasizing nuclear power in favor of solar and coal last May and June, not only at the State Committee, but at the Ministry of Power and Electrification, the designer and operator agency for all types of power plants in Russia. But since the first Russian group visited Oak Ridge in late 1959, a lot of reactor time has been logged over the world.

Detente

Our interaction with Russia was pursued in 1958 as a result of the Geneva Conference in

1955, where President Eisenhower met with Khrushchev and Bulganin, followed by the Atoms for Peace Conference in Geneva in 1958. E. P. Epler, then in the Instrumentation and Controls Division, had gone to Russia with an exchange group in automation and control. It was widely regarded then as a feat only slightly less remarkable than going to the moon; but in 1959, after the first Russian visit to ORNL, for one carefully guarded day it looked as though communications with that hitherto closed country were beginning to open up. (As the 1967 edition of the *Encyclopaedia Britannica* put it, in the entry under "Eisenhower," "The new Eisenhower who emerged in 1959 and delighted the national press was actually an expression of his true basic nature.... The one idea that he had brought to the presidency that did not match his character was that of the relatively 'passive' president.... There came a bold new approach to foreign relations, one that would have been disapproved of by Secretary Dulles. Premier Khrushchev was invited to the United States for a tour and for face-to-face talks with Eisenhower in September of 1959.... A period of *detente* arrived. ..." This, long before Kissinger.)

There ensued a stampede to Russian language classes in Oak Ridge; a Russian-speaking table was organized at the Laboratory cafeteria; in-house courses were offered staff members; and courses offered in the Adult Education Program, taught by Rose Germaine and me, suffered from oversubscription. Within six months this fever had reversed to a precipitous flight away when the U-2 incident of 1960 threatened again to bring us to the brink of another major crisis.

The exchanges with Russia in the fields of peaceful uses of nuclear energy have continued since then in much the same up-and-down pattern, generally in synchrony with the political and military developments around the world and the U.S. response to them, under Presidents Eisenhower, Kennedy, Johnson, Nixon, and Ford.

In 1963, I was asked to work for the AEC Division of International Programs as an interpreter during the visit of the new Chairman of the U.S.S.R. State Committee, A. M. Petrosyants, and his party to the United States. AEC Chairman Glenn Seaborg and an American group had visited Russia earlier that year, and the Nuclear Atmospheric Test Ban Treaty had been signed by both governments. It was an auspicious occasion. Chairman Petrosyant's first stop after New York was to be Oak Ridge, but the plane, former President Eisenhower's "Columbine," developed engine trouble, requiring a forced landing at Andrews Air Force Base in Maryland. The next day, in Oak Ridge, in response to an apology from Dr. Seaborg for the delay, Petrosyants made his now classic reply:

"Well, at first I did wonder about it when the second propeller was feathered, but then I decided that it really was no concern of mine; both the airplane and the responsibility were yours. It was your worry."

However, the assassination of President Kennedy shook the nation while the Russian group was at the Lawrence Radiation Laboratory in Berkeley, and all joviality was from then on at an end. Because of the violent emotional reaction at that period in history, coupled with the national uncertainty occasioned by the unprecedented event, that was perhaps a time of record intensity of anxiety for such visits. At one point, as the car bearing the Russian visitors stopped to pay the toll on the Golden Gate Bridge, a voice on the toll collector's radio was heard to say, "The assassin has now been identified as a man who had once defected to Russia. . . ." Every occupant in the car looked straight ahead, not speaking.

Still, the smooth resilience of the American governmental system bridged the crisis very well, and the visit continued, to include stops at the Reactor Test Station in Idaho, Nebraska's Hallam and Illinois's Dresden demonstration power reactors, the Enrico Fermi experimental LMFBR in Michigan, and Argonne and Brookhaven National Laboratories.

Decade of Progress

The decade of the sixties was an exciting, optimistic one for the nuclear reactor business. The main directions of power reactor commercialization were taking shape out of the wealth of ideas, research, tests, and demonstrations that had characterized the preceding decade. There was confidence and enthusiasm in the American nuclear community, and most Russians appeared genuinely impressed. Their appreciation was not only for the nuclear developments but for American productivity, as well as the tremendous variety of American life.

On one trip in the United States a Soviet visitor wondered about the "trailer cities" that were beginning to be visible on the outskirts of many American cities. When the phenomenon was explained, he expressed doubt, speculating that these were only cheap aluminum shells put up "to shelter the homeless." The bus was thereupon diverted to a trailer park where a sales lot was also in operation and the visitors were toured through all sizes and shapes of the "homes on wheels." I must say, it was a revelation to many of the Americans as well as to the visitors, for the luxurious and moderately priced trailers were still a new phenomenon in the early 1960s.

"Well, now that your visit is almost over, was America what you expected?" asked an AEC host of a middle-aged Soviet scientist in 1964.

"I have read some Russian books about America, and many American books in translation as well," was the reply. "But before this visit, I do not think I knew anything at all about the real America."

In early 1964, the Oyster Creek Power Station contract was hailed in the United States as the first step of nuclear power into the competitive commercial market at a capital cost of about $142 per kilowatt. In Russia at that time, demonstration power reactors were still under construction, although an Arctic icebreaker with three pressurized water reactors for propulsion had been operating for about five years and a pressure tube test reactor had been driving a 5-MWe turbine since 1954. Now, 17 years later, the United States has about 39,000 MWe of commercial nuclear installed capacity to Russia's 6000. But the U.S. industry seems besieged on all sides, while in Russia there appears to be only confidence, backing up a firm program committed to a total nuclear capacity of 30,000 MWe by 1986 in the European sections of the country. This location of nuclear

At the reactor test station at Melekess (now renamed Dimitrograd) near the city of Simbirsk (renamed Ulyanovsk), the Seaborg delegation lines up in front of a sculpture built to celebrate the discovery of atomic fission.

power in the high-population-density sections of the country, where fossil fuel resources are depleted, is supplementary to the expansion of coal-fired capacity near the large deposits of low-calorie coal in remote areas east of the Ural Mountains, in Asia. The electricity generated there will apparently be transmitted at very high voltages for distances of over 1500 km (which is also a considerable technological challenge). One exception to this geographic emphasis for nuclear power is an electric and district heating station, consisting of four pressure tube reactors, which is located about 250 km north of the Arctic Circle in Siberia. The Russian BN350 in Shevchenko, a sodium-cooled fast "breeder" reactor, is rated at 1000 MWt, furnishing both electricity and desalted water, with some interruptions, for three years now.

One reason for the seeming change in relative outlooks for the two programs is that the Soviet context for planning and development of nuclear power has included none of the strident public debate about safety that has dominated the American scene. Needless to say, there has never been any picketing or occupation of a construction site. The documentation for the power plant licensing process is not open, even if there were any intervenors to demand its disclosure. But all these factors are now routine jumps in the steeplechase that American industry must run to reach licensed and fully authorized operation of a nuclear power plant.

The New Russians

After 1966, a growing proportion of Soviet scientists who came to the United States were of a new generation, one that only dimly remembered World War II and the Stalin period of Russian history. For this new generation, among the scientists in particular, English had become the second language.

"Do not base yourself on interpreting," said an electrical engineer to me in 1966. "In ten years, all our young people will know some English, and all our scientists who visit America will know English well."

I have found that he was more correct than even he, perhaps, would have expected. In addition to the constant and all-pervasive use of English words in Russian technical literature, modern Russian colloquial usage substitutes English words even in cases where Russian words exist to express the meaning. Beyond that, I was surprised this past year to hear songs sung in English in restaurants in Dimitrovgrad, as well as in Moscow and Leningrad. The sound of the music has also shifted since 1964 toward what, I think, is called "rock."

Still, when it comes to fine points of discussions and pronouncements with bearing on negotiations, Soviet representatives stay with Russian, while Americans stay with English. In this context it is essential for an interpreter to stay alert. I found this out to my distress in February 1974, when a high Soviet official, in the middle of a luncheon address, suddenly shifted to a comparison of technological development of the United States vis-a-vis Russia.

"Who did he say was Number One?" I agonized, for a full 10 or 20 seconds as he continued with easier generalities. In that case, I guessed right; he had said that the United States was ahead.

Chairman A. M. Petrosyants of the U.S.S.R. State Committee for the Utilization of Atomic Energy in 1963 led a delegation of Soviet scientists on a tour of U.S. nuclear facilities. Here they visit the National Reactor Testing Station in Idaho Falls...

...Plasma Physics Laboratory at Princeton University...

Among the ordinary people, in Russia, expressions of admiration for American industry, science, culture, and other achievements are not

...Argonne National Laboratory...

...ORNL...

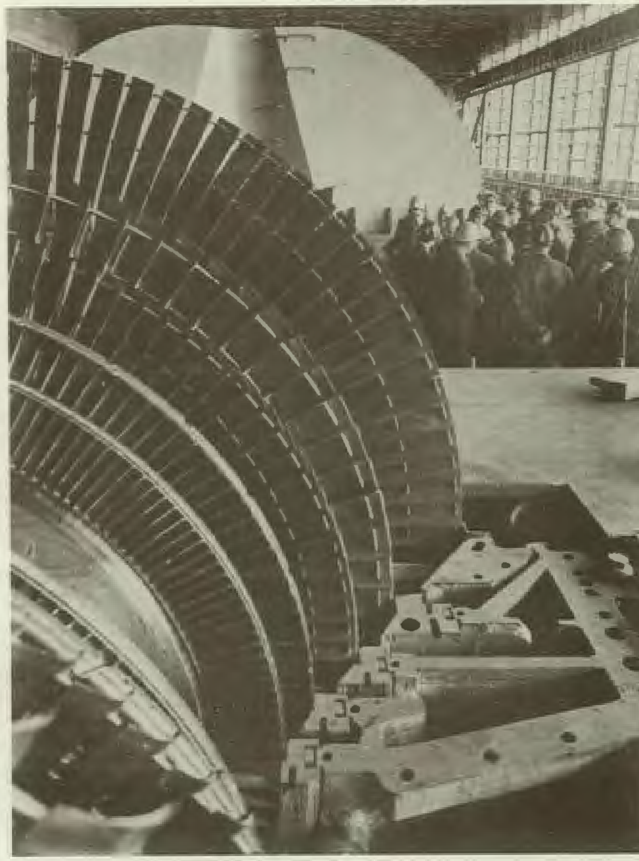
...Hallam Demonstration Reactor near Lincoln, Nebraska...

...Enrico Fermi Fast Breeder Reactor in Michigan.

uncommon. A dramatic example of this occurred in October 1974, on a Soviet IL-18 airliner flying from Moscow to Kharkov. William A. Anders, AEC Commissioner and former Air Force astronaut, who had been a member of the Apollo 8 crew that first orbited the moon, was the leader of the small group of Americans on board. About 30 minutes after takeoff, an announcement of Anders's presence on the plane was made over the PA system. There followed a rush of about a hundred passengers to the front of the plane where the astronaut was sitting. Anders was kept busy for almost an hour signing autographs and shaking hands. Later he was invited to take the controls of the four-engine turboprop, and he maneuvered it a bit on the approach to Kharkov.

Another incident that stands out in my memory is an encounter with a taxi driver in Moscow (although taxi drivers tend to be "characters" all over the world). A group I was with, leaving a conference somewhere in the city, was bound for

One of the huge turbines at the Leningrad Atomic Power Station, still under construction in 1971 at the time of the U.S. visit by the delegation led by Glen Seaborg.



the American Embassy. A passing cab stopped for us, and, since we had not boarded at a hotel or terminal, I wondered if the driver would know where the American Embassy was located.

"Do I know where it is?" he replied rhetorically. "If you had asked me to take you to the American ambassador instead of just the embassy I would have gotten you to him."

Then, realizing that he had an American audience, he launched into a soliloquy on his view of American-Soviet relations.

"Why did Nixon bring Brezhnev a Cadillac?" he continued. "Brezhnev has enough of them now. Tell Mr. Ford, when he comes here, not to bring any Lincoln for the big shots, just some little Fords for guys like me."

And so, in the light of all this, I can hear the question—as I have heard it a thousand times or more: "So is everything all right now between us and the Russians?"

And the answer, so obvious it seems trivial, is "Of course not."

True, it is no longer a rarity for someone from Oak Ridge, especially in fusion work, to go to Russia, nor for Russians to come here. Indeed, many American corporations have permanent offices in Moscow. But many problems between the two countries, far from being resolved, are now, unfortunately, worse than ever. Some new problems, unforeseen in 1959, have arisen, while some "old" problems that were thought to be a thing of the past are once again looming on the horizon. But total "solutions" for such problems are not now expected, nor even thought to be possible; only deferral, deemphasis, and/or diffusion of issues that threaten to polarize mankind are now perceived to be attainable.

Although the leaders of both countries seem to recognize that, historically, the natural course of human events has been for hostility between centers of power to escalate automatically into disastrous war, today's situation is different in several ways. The power of weaponry, the facility for instant worldwide communication, and the economic problems that beset all the countries of the world are but three of these differences.

The complexity of the world, and of both the United States and Russia in particular, is now so great, and the functions within both societies so stratified, that to a significant extent these strata (military, industrial, technical, political, cultural, etc.) may be approached as separable areas for specific programs and to the good of both nations.

At the level of an engineer and interpreter, however, ERDA's "Russian connection" has been an unusual task: intense, difficult, frustrating and even abrading at times, but always fascinating and challenging.

Take A Number.....

BY V. R. R. UPPULURI

WHICH REPRESENTATION TO CHOOSE?

It is well known that an expression in mathematics can at times be represented in several different ways. Anyone who has taken a course in algebra or trigonometry knows that one proves several identities as exercises and at times may wonder about the reason and usefulness of such an endeavor.

The following number, which has mathematically equivalent representations, beautifully brings home the usefulness of different representation formulae. Especially when one needs to compute a number which hinges on approximations of numbers like $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, e, π, etc., it even shows the need for a careful choice of a representation. The following example was presented by Professor K. Frankowski, University of Minnesota, in a seminar.

$$\left[\frac{\sqrt{5}-2}{\sqrt{5}+2}\right]^3 = [(\sqrt{5}-2)^2]^3$$

$$= (9-4\sqrt{5})^3 = 2889 - 1292\sqrt{5}\,.$$

If we wish to compute the above number on a calculator we need to depend on the approximation of $\sqrt{5}$ built into the machine. For instance, if $\sqrt{5}$ is approximated by 2.25, we get the following values: $(1-17)^3$, $(1-16)^3$, 0, and -18. For a given approximation of $\sqrt{5}$, it becomes imperative to choose a good representation for the computation at hand.

It is rather interesting to note that the most difficult thing to do on a computer is to find the difference between two numbers of the same magnitude.

The View from the Top:

Mel Feldman's Year as ANS President

By CAROLYN KRAUSE

June 8, 1976, was a remarkable day in the life of Melvin Feldman as well as in the history of American technology. It was a day of stunning victory for technology in general and nuclear power in particular, as California voters by a two-to-one margin defeated "Proposition 15," a measure which would have practically shut down the nuclear industry in that state. It marked the first time that technology had been put to a popular vote. And in the happy outcome of this day's referendum, Mel Feldman found some vindication for his belief that working scientists and engineers can and should communicate with the public and impart a reasonable, balanced view of the benefits and risks of nuclear power.

Feldman, program manager of engineering systems for ORNL's LMFBR Fuel Recycle Program (headed by Bill Burch), was president of the American Nuclear Society from June 1975 through June 1976. Before coming to Oak Ridge in April 1975, Feldman was an associate director of Argonne National Laboratory-West Division. Since many ANS presidents are directors of research laboratories or presidents of corporations or deans of universities, Feldman called himself the "peasant president." Inherent in this appellation is Feldman's faith in the integrity, credibility, and effectiveness of the working scientist and engineer in fielding the questions of laymen when they are confronted with the choice of retaining or rejecting nuclear power as an energy option.

"As president, I took on the challenge of encouraging and exhorting members of the American Nuclear Society to get out and talk to the public in response to the opposition," Feldman says. "In California there were about 100 ANS people who took the time to become involved and try to handle the public's questions. We discovered that there were two publics. There was the heavily polarized public who had already decided that nuclear energy was no good—a minority group that is extremely vocal. Then there was the 95% remaining who were neither polarized anti or pro but who all of a sudden had to respond to a question that they knew little about. This segment wanted some basis to make a decision on."

Playing Point Counterpoint

Feldman believes that the technical community won over a segment of the California constituency by adopting the strategy of the antinuclear group, providing arguments trenchant enough to

Just two months before becoming the 21st president of the American Nuclear Society in June 1975, Mel Feldman left his administrative position as associate director of Argonne National Laboratory-West in Idaho to become program manager of engineering systems for ORNL's LMFBR Fuel Recycle Program. He is not a newcomer to Oak Ridge, however. In 1950, after earning his B.S. in metallurgical engineering from Purdue University, Mel arrived here to pursue radiation damage studies. Over the next six years he worked on the Army Power Package Reactor and molten-salt systems and, with his colleagues, developed the first remote metallography system by which one could remotely cut, polish, and microscopically examine a radioactive sample for radiation damage. While here, Mel obtained his M.S. in metallurgy from the University of Tennessee. In 1956 he left for Idaho Falls, working first for Westinghouse Electric Corporation and then Argonne-West (beginning in 1960) at the National Reactor Testing Station (now Idaho National Engineering Laboratory). There his research concerns included radiation damage to navy reactor cores, fast reactor fuel reprocessing fabrication, and nondestructive examination of fuel elements. He later became manager of Argonne-West's Fuel Cycle Facility and Hot Fuel Examination Facility. In the late 1950s Mel became active in the ANS when he joined the Hot Laboratory Committee, which evolved into the Society's Remote Systems Technology Division. His steady rise in the organization culminated in his election as president. In the candid interview that follows, he tells of his term in office at a time when the public wrestled with the question of whether to keep or kill nuclear power as an energy source.

neutralize their position. As Feldman puts it:

"You can't just let them (the antinuclear spokesmen) go on talking because they do quote facts incorrectly and they have emotional political views. All you can do is play point counterpoint, appear on the same stage, yell as loud as they yell, and try not to make some of the atrocious statements that they make. The antinuclear people made absurdly political statements and were so obviously in error in many of them that they were plainly vulnerable to argument."

Reflecting on the import of Proposition 15 in the history of technology, Feldman says: "The engineering and scientific community had never been called to task by the public, at least within my memory. There had not been public involvement in the decisions of technology. It turns out that Proposition 15 represented what I thought was the beginning of a continuing challenge of technology by the public. I did not find the entire American public antinuclear, but I did feel that the public was going to question technology. And that's very healthy. There's a balance between the time it takes to exercise our form of government and the decisions that need to be made. There was never any question of the public's right to do what it was doing. There is a question of whether there is adequate time for this system to fully function. Proposition 15 in California made the entire technical community do a little bit of introspection that was extremely healthy."

Feldman views the California experience as a milestone in the attempt of technologists to communicate with the public. But it was a milestone colored with disappointment.

"The end point was not a totally satisfactory one as far as I was concerned," Feldman said, "because the arguments we used that convinced the public to vote against the initiative mainly concerned job security and energy as it affects the way of life. This was unsatisfactory to me because I think nuclear energy can win arguments on its own merits. But this was the only avenue available because we have not yet solved the problems of talking to the public in its own terms on the specifics of nuclear energy.

"Furthermore, we started off with the psychological disadvantage that our introduction to the public was through the atomic bomb. Many of us learned to start off our talks with the fact that a nuclear reactor cannot blow up, that it is not a bomb. But the dissociation is very hard to establish. When I stood before an audience, I sensed that they saw a mushroom cloud rising behind me."

Public Wants Absolute Answers

Another problem that technical people encounter in relating to the public, Feldman notes, is the difficulty that laymen are perceived to have in accepting qualified responses. "They were used to interacting with the political animal. When a politician addresses the public, a high probability means absolutely yes and a low probability means absolutely no. To the technologist, that's not true. And so the public was very surprised when we refused to say that it is absolutely impossible to have a nuclear accident. They would have been more comfortable if we had told them that, but we're not trained to say that."

A metallurgical engineer, Feldman believes that engineers should be trained to communicate with the public on the social impacts as well as the technical aspects of engineering. Many working engineers have not been trained in sociology and economics simply because technology has become so complicated that the academic curricula for engineering students have been devoted almost entirely to technical fare.

"Science is the promotion of a technical concept," Feldman says, "and engineering is the transition of that concept into a people-useful product. The public asks, What are you doing for me or to me? The engineer isn't trained to respond."

But the technical community has been awakened to the need for a dialogue between engineers and the people whose lives are affected by the accomplishments of the engineering profession. Says Feldman: "I think the new generation of engineers—the ones that will be successful in the future—are engineers with a round technical base who have an understanding of the economics and the social and environmental impact of the trade. And that makes engineering awesomely complicated.

"I would hasten to add that there has been a better response by the technical community to broaden their knowledge to include the social aspects of their field than there has been from the social scientists and lawyers to understand the technical aspects of their fields."

Representing the American Nuclear Society, Feldman talked to the press and the public. He talked as an engineer who believes that "inherent in the definition of an engineer is the ability to communicate with the public." He felt that the people would look on him and his ANS colleagues as persons trained to earn a living in the nuclear field and capable of answering lay questions on nuclear technology, just as doctors answer questions on medicine and lawyers respond to laymen's queries on legal matters. "Your training is primary and your prejudice is secondary in the minds of the lay public," Feldman says.

Overcoming Limelight Jitters

At first it was not easy for Feldman to work in the public limelight. "When I was exposed to the press, radio, and television," he recalls, "my first reaction was that I wanted my mother and a security blanket. Then it wasn't so traumatic, and I started to enjoy it. I chided the press for its exposes and responses to exposes on nuclear energy. I pointed out that major newsmagazines ignored the pronuclear statement with 25,000 signatures that ANS sent to the White House but gave considerable play to the antinuclear petition circulated by the Union of Concerned Scientists and signed by 2300."

Feldman successfully argued that the Society should adopt a pronuclear stance in its dealings with the public. "Fundamentally," he recalls, "the American Nuclear Society had historically been neutral on questions such as this. It had held itself in what I considered to be a position of celibacy, reflecting a desire to stay uninvolved.

"I raised and brought to the ANS board of directors the fact that we were not neutral. I said that the weight of evidence of our own technology, independently analyzed, left us not neutral. We were pronuclear not because of a prejudice and not because we were trying to serve our own employment benefits but simply because of the weight of the evidence that we had ourselves carefully generated.

"The ANS board of directors," Feldman adds, "owned up to the fact that we did have a responsibility to transfer to the public the weight of the evidence that we had generated. Still, many Society members felt they should sit in judgment and settle questions brought to them—a paternalistic attitude that I found completely wrong. We're not the judges but the participants."

During his presidency, Feldman had to address questions about the energy dilemma, on one of the two horns of which is impaled society's increasing demand for energy and on the other its requirement for protection of the public health and environment.

Mel Feldman chats with visitors at the American Museum of Atomic Energy in Oak Ridge.

"Nuclear energy has the least environmental impact of all the energy sources," Feldman told his audiences. "It doesn't produce dust, gases, fly ash, and carbon dioxide. The only impact is the fear of radiation exposure. In time, people will realize that the environmental impact of nuclear makes it the most acceptable."

How Much Will Energy Cost?

Feldman believes that the public should be more involved in questions about the economics of environmental protection. "Nobody has told the public that there are degrees of impact and degrees of protection," Feldman says. "For example, to remove sulfur dioxide from the smokestacks of coal-fired steam power plants, it may cost $100 million to take out the first 90%, another $100 million to remove the next 6%, another $100 million to take out 2%, and another $100 million to remove an additional 1%. The public is never given the option to chew on what degree of protection it wants."

The whole question of economics gives rise to the matter of energy costs, about which Feldman has plenty to say. He tells his audiences that the "free lunch" is over, that cheap energy has gone up the stack, that "your grocery bill and energy bill will soon be about the same." He foresees an unhappy consequence of rising energy costs, particularly if Americans continue to waste energy.

"I look at personal expenditures as being on three levels: necessary, discretionary, and luxurious. Our standard of living is measured by our discretionary income. If you have a seven-room house, four rooms are discretionary. Having one car is necessary, but having a larger car or two cars is discretionary. People won't react positively as energy costs absorb increasing portions of discretionary money. I'm concerned that the public reaction could take the form of an irrevocable decision. When power shortages accompanied by high power costs occur, there is a high probability that the public could rescind utility franchises and nationalize the utility industry. That means the public would be paying for energy through taxes as well as electric bills. And when they discover that their energy costs are not reduced by the change, it will be difficult to reverse the decision."

Based on what he learned from his presidency and from subsequent events, Feldman believes that nuclear power is here to stay as a worldwide energy source. He notes that in 1976 seven states (California, Colorado, Arizona, Montana, Ohio, Oregon, and Washington), one-fifth of the nation's plebiscite, rejected initiatives to curb nuclear power. He attributes this "positive vote for nuclear power" largely to the credibility of "individual technical workmen as represented by members of the ANS."

During his term, he traveled extensively, visiting Japan, Thailand, Iran, Israel, Italy, France, and England. Says he: "I had an opportunity to interact with citizens of countries that didn't have the freedom for long discussions about how their energy demands would be met. They were not capable of producing 60 or 70% of their own energy. They were almost totally reliant on imports. They were making no bones about the fact that they were going nuclear."

When he returned to the United States, he was asked what would be the consequences to the internationalism of nuclear energy if the American efforts slowed down. Feldman had not asked this question, but he realized that he had been told the answer. He knew that highly industrialized exporting nations regarded energy as essential to their ability to manufacture and export. If more energy means nuclear power plants, then these nations will continue to build such plants. Unlike the United States, such nations disdain the question, *Should* we generate more energy? as they continue to build up their energy-generating capability. Feldman learned that these nations foresee that the United States may slip from its position at the top of the manufacturing and exporting ladder if it continues to place the emphasis on energy conservation and at the same time erect stumbling blocks for its nuclear industry. Likewise, these nations envision their positions in the manufacturing and exporting market moving up because of their programs of building nuclear plants to generate energy.

ANS Appeals to Foreigners

Feldman's interest in traveling abroad also stemmed from a desire to explore the potential of the international aspects of the ANS. The ANS has 12,000 members, 90% of whom reside in the United States. The rest belong to overseas chapters in Belgium, West Germany, France, Italy, Brazil, and Japan. A number of the foreign members, who work in autocratic scientific organizations, find the ANS appealing because of its democratic nature. Says Feldman:

"What I did discover in my travels abroad was that the recognized entity in the nuclear field for the transfer of nuclear technology was the American Nuclear Society. It is the recognized transfer, contact, and distribution point. It is held in high esteem overseas, probably because of its demonstrated fairness. Foreign scientists and engineers are not used to having an article judged for its technical content without consideration for the author's established eminence. That's the democratic attraction of the ANS."

Internationalization of the ANS has not come about, however, because of the difficulty of justifying such a change on the basis of only 10% non-American membership.

The formation of new overseas chapters of ANS was resisted in some countries. England, for instance, has its own British Nuclear Energy Society. But the British are eager to discuss the nuclear energy controversy with ANS representatives. In this context, Feldman delivered a one-hour talk on nuclear parks to 200 people at Seascale, England, including members of the British equivalent of the Sierra Club and the Union of Concerned Scientists. He then spent two hours fielding the difficult questions posed by people concerned with the social and environmental impacts of nuclear power. Says Feldman: "It was an extremely exciting evening because there were people there who had genuine concerns and who asked questions that showed those concerns."

Professionalism vs Unionism

One of the issues that Feldman had expected to deal with as ANS president was the question of whether the ANS would undergo a transition from a technical society to a professional society. He felt that there would be a growth in the number of ANS members who wanted an enhanced leverage in their relationship with their employers. Says Feldman: "There are pressures that build, particularly at times of employment stresses (wages or jobs) that indicate an interest in unionism. A professional society is a viable alternative to a union movement."

"The ANS," he says, "is a technical society, but there were rumblings that I had been aware of for five to ten years that the individual membership might want it to become a professional society, such as the American Medical Association or the American Chemical Society."

Feldman concluded during his tenure as ANS president that the time was not ripe for nuclear scientists and engineers to talk unionism or professionalism with any degree of seriousness. Concerns of that nature are fostered by hard times, such as a downturn in the nuclear industry, when people worry about their jobs.

"The union question always comes up at the wrong time," Feldman says. "Then, fear of the actions of management results in people looking for a protective mechanism such as a professional organization or a union, and those steps are best considered outside the trauma of unstable employment."

Even though the anticipated issues of professionalism and internationalism never really came up during his presidency, Feldman derived great satisfaction from his time in office, largely because

Mel Feldman and Robert Seamans, former ERDA administrator, face an Idaho Falls audience at a 1976 meeting of an American Nuclear Society chapter.

of the successes he and the Society experienced in making the public more aware of the benefits and risks of nuclear power.

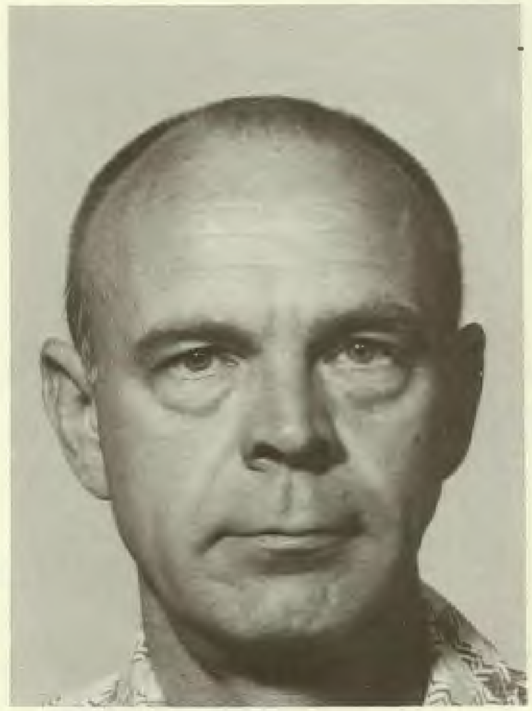
"I was honored by the presidency," he says. "I was for a short time put in a Cinderella position. I was exposed to the public arena much in the manner of a political candidate. I was provided a forum for expressing ideas. I was responsible to the Society and to my colleagues, but the flavor of statements reflected the individual.

"Personally, I would have to credit ORNL for an attitude that I found quite sophisticated in allowing me to pursue the requirements of the presidency of a professional society. I was given complete freedom to judge the balance between my Society and Laboratory responsibilities."

Staff quote:

*"A number of the gardens at the Botanical Institute in Tbilisi were devoted to medicinal plants. One group is currently studying the use of certain plants in preventing and curing baldness. This kind of research seems unusual to an American botanist, but in the Soviet Union a great amount of faith, and perhaps knowledge, ascribes to the curing power of various medicinal plants. While eating with scientists, we were continually told of the ability of this or that plant to cure liver disorders, etc. Although in this country such conversation falls into the class of folk or herbal medicine, which most people don't believe, many people in the Soviet Union, including many scientists, firmly believe in such things."—**W. C. Johnson,** describing a recent visit to the USSR.*

R&D *Achievement* at ORNL



William E. Kinney

Neutron Scattering

For four years, Bill Kinney of ORNL's Neutron Physics Division had made the most precise low-energy neutron scattering measurements ever for such important reactor materials as iron, sodium, and silicon (principal constituent of concrete). His impressive array of data, described as "beautiful" by colleagues, allows a tenfold improvement in the observation of details of the interaction of neutrons with target nuclides over what have been measured by others. Several days before his death from an automobile accident on December 6, 1976 (which also killed Mary Buffington, an ORNL keypunch operator), Kinney learned from his colleague Francis Perey that the data had stood the test of theory.

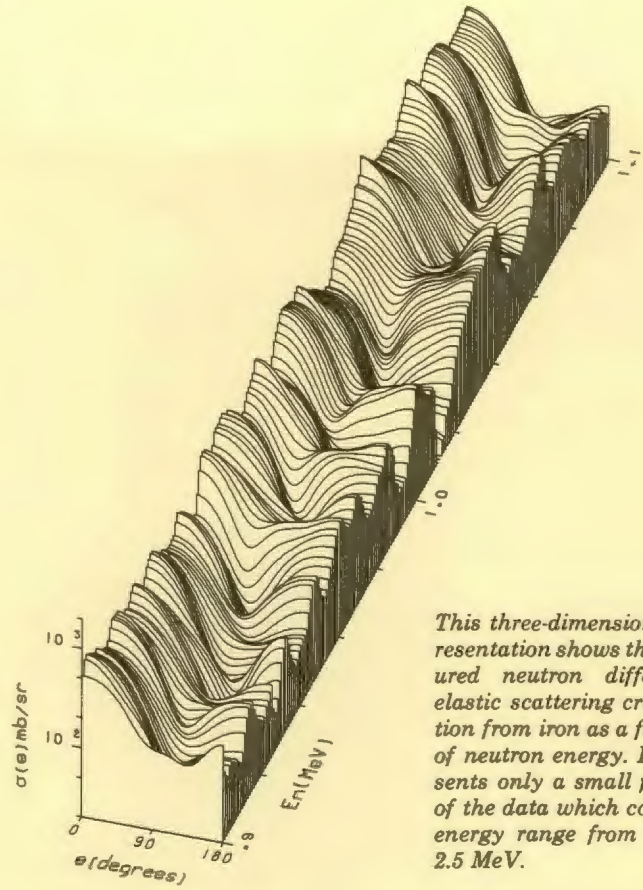
"I had started to analyze Bill's data using the R-matrix theory developed by Eugene Wigner in the 1940's, and the agreement was fantastically spectacular," Perey said. "Practically all of our wild expectations for the last three years appear to be fulfilled in the quality and usefulness of the data."

The data obtained at the Oak Ridge Electron Linear Accelerator, which will be incorporated in the Evaluated Nuclear Data File (ENDF/B), are of interest not only, from a fundamental view, to nuclear physicists, but also to reactor designers, since they yield detailed information concerning the scattering (both elastic and inelastic) from the resonances found in the interaction of neutrons with these nuclides.

Kinney's early work in neutron scattering was accomplished from 1962 to 1970, using monoenergetic neutron beams from the Van de Graaff, where he acquired data from 4 to 8.5 MeV for over 25 nuclides important in nuclear applications. But the data available using similar techniques below 2 MeV were considered unreliable due to the important resonances at low energies. Since this low-energy range closely matches the energy spectrum of neutrons emitted in fission, Kinney undertook to measure low-energy neutron scattering (elastic and inelastic) by adapting the techniques he had used at the Van de Graaff to ORELA's white neutron source. (The beam contains a continuum of neutron energies which were separated by the time of flight of the neutrons over a 40-m flight path.) Kinney used several neutron detectors to determine the probabilities of elastic and inelastic scattering at different angles as a function of incident neutron energy.

Perey has demonstrated that R-matrix analysis of the observed angular distributions allows quite unambiguous assignments of the spins and parities of the resonances. Thus this method promises to constitute a major tool for determining resonance parameters over a wide energy range. This information is important to reactor designers, since it affects the amount of absorption of neutrons in reactor components.

A gifted computer expert, Kinney also pioneered the use of computerized phototypesetting at the Laboratory, having written the first program, still in use, for such applications. During his 24-year career at ORNL, he became a Monte Carlo and neutron transport expert, having published 11 professional journal articles and 36 ORNL reports. Over the years he worked closely with Perey, who supervised Kinney's thesis prior to his earning a Ph.D. from the University of Tennessee in 1967.—C.H.K.



This three-dimensional representation shows the measured neutron differential elastic scattering cross section from iron as a function of neutron energy. It represents only a small fraction of the data which cover the energy range from 0.03 to 2.5 MeV.

lab anecdote

Turning Professional

Economic determinism says that there is a limit to the abuse you will take from a tough before you give up the five-dollar bill you are standing on.

When Bob Coveyou came to the labs at X-10 during the war, he was one of less than half a dozen health physicists. He lacked a few credits for a college degree, and so he was a nonexempt employee who punched a time clock and was not permitted to have general clearance to go to the library and read reports marked "Restricted Information." Even the reports which he himself wrote, reports of radiation surveys in the offices and labs and work areas, he could read only by asking his superior for them and reading them in that office. How does one enlighten management, both local and in the security sections, to use experience in lieu of education toward promotion?

When 200 curies of barium 140 were first produced in the old 706-C building in late summer of 1944, a health physicist was needed to monitor the work, and Bob was the only one available and willing for the day and night job, in fact four or five consecutive days and nights. Perhaps only a coincidence, but several weeks after the payroll office saw the price of his work at time and a half, he was promoted to a professional post, freedom from the time clock, and the liberty to go to the library and check out the reports he wrote.—H. S. Pomerance.

OAK RIDGE NATIONAL LABORATORY *REVIEW*
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Awards and Appointments

W. L. Russell, the first member of the ORNL staff to be so honored, was selected by unanimous vote to receive this year's Enrico Fermi Award, given in recognition of outstanding achievement in the field of nuclear science.

Ray Stoughton and **Milt Lietzke** have been elected Fellows of the New York Academy of Sciences.

James L. C. Ford, Jr., has been elected a Fellow of the American Physical Society.

The American Nuclear Society has announced that the following ORNL staff members have been elected Fellows of the society: **A. P. Fraas, A. L. Lotts, M. W. Rosenthal, J. L. Scott,** and **R. G. Wymer.**

A. L. Lotts was chosen to receive the E. O. Lawrence Award this year for his work in the development of the thorium-233–uranium fuel cycle. He is the second member of the ORNL staff to be so honored and is, like the first designee, J. R. Weir, a member of the Metals and Ceramics Division.

Since its establishment, ERDA has selected a half dozen outstanding members of the Headquarters staff for receipt of the ERDA Distinguished Service Award. This year a correlative honor, the ERDA Distinguished Associate Award, was bestowed on a select few staff members of contracting laboratories. First at ORNL to receive this award was **John Clarke**, so honored for his many ORMAK successes.

Larry T. Corbin has been appointed chairman of Committee C-26 on Fuel, Control, and Moderator Materials for Nuclear Reactor Applications of the American Society for Testing and Materials.

Gordon Fee has been named "Eminent Engineer" in the Tau Beta Pi Association, a national engineering honor society.

An exhibit prepared by **Terry N. Tiegs** and **Tommy Henson,** entitled "Distribution of Uranium, Cerium, and Cesium in Irradiated TRISO-Coated 85% UO_2–15% UC_2 Fuel Particle," won first place in the optical micrograph division at the American Ceramic Society's 1976 Ceramographs exhibit held recently in Cincinnati. Another exhibit, designed by **Victor Tennery** and Henson, received honorable mention.

At the 1976 international metallographic exhibit, cosponsored by the American Society for Metals and the International Metallographic Society, in Seattle, exhibit awards were won by **James Bentley, Edward A. Kenik,** and **Ray W. Carpenter;** Tiegs and Henson; and **Nicholas H. Packan.**

Chuck Scott and **Gene McNeese** have been named associate directors of the Chemical Technology Division.