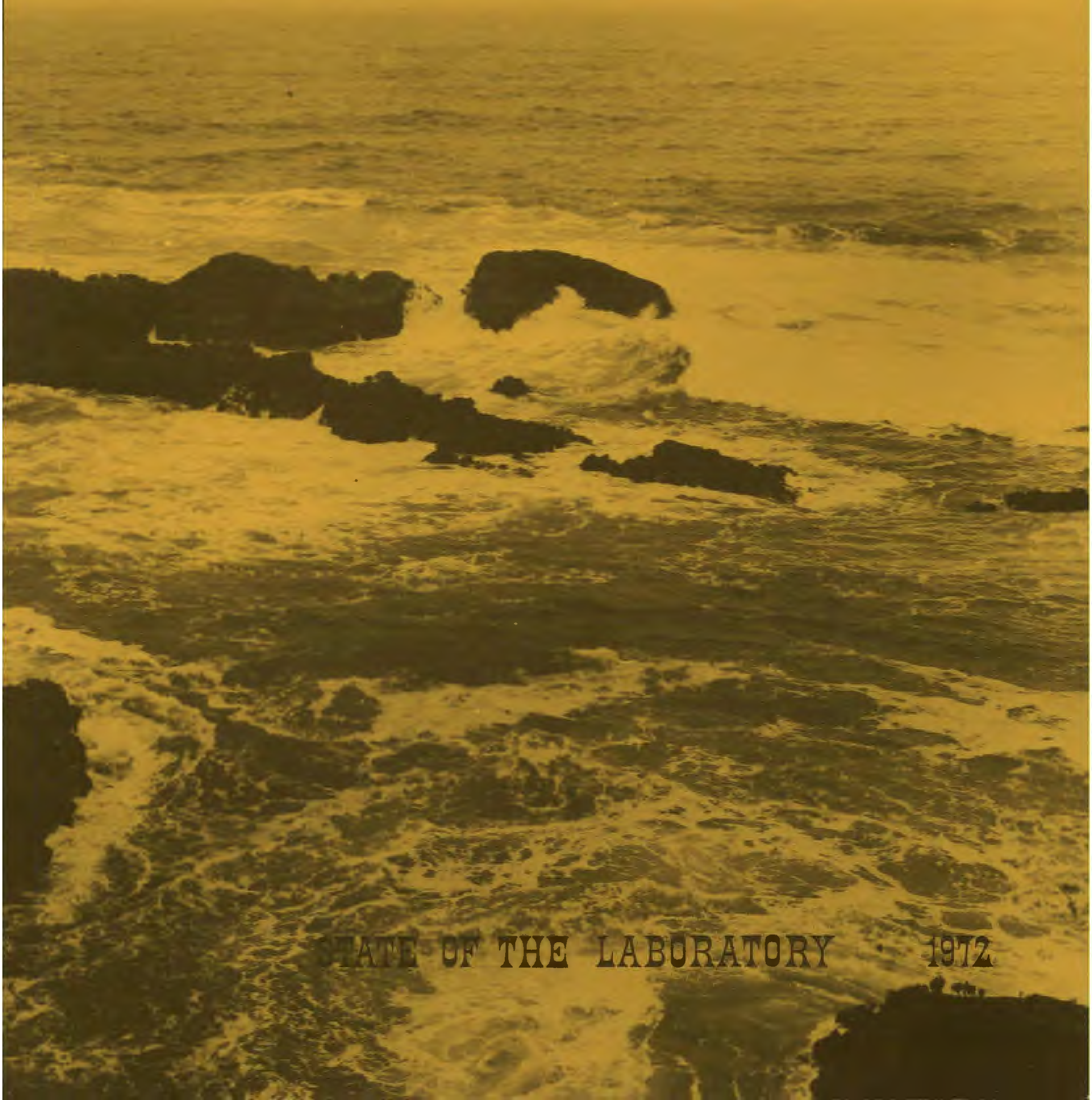
Review

WINTER 1973

OAK RIDGE NATIONAL LABORATORY



STATE OF THE LABORATORY · 1972

THE COVER: The Pacific Ocean as seen from a promontory near Mendocino, California, the proposed site for a power reactor. The photograph was taken by Deputy Associate Director Sid Siegel and is included in the Environmental Impact Statement for the Mendocino reactor. Impact statements were among the highlighted activities of the Laboratory described in A. M. Weinberg's State of the Laboratory address in December.

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Review

OAK RIDGE NATIONAL LABORATORY

VOLUME 6, NUMBER 1 **WINTER 1973**

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

STATE OF THE LABORATORY 1972

Alvin M. Weinberg

In recent years it has been my custom in these talks to point out that ORNL is where the action is: we find ourselves increasingly at those critical intersections of technology and society which underlie some of our country's primary social concerns. During 1972 these involvements have boiled over into a series of incidents that make many of us long for the good old days when what we did at ORNL was separate plutonium, measure cross sections, and develop instruments for detecting radiation.

ECCS Hearings

Perhaps the most exhausting of the Laboratory's encounters with this interface between science and society has had to do with the Hearings on Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Nuclear Power Reactors (to give the hearings their full name). In brief, the issue is this. The probability of a serious reactor accident is extremely small; but no matter how small this probability, the entire nuclear community is dedicated, through careful engineering and analysis, to reducing this probability. The most serious accident that has been hypothesized is the so-called loss-of-coolant accident (LOCA): a double-ended pipe rupture that would deprive the reactor of its coolant. To mitigate the consequences of such an event, light-water reactors are equipped with emergency core cooling systems (ECCS) that are designed to keep the core flooded under all possible situations. Without such cooling one cannot prove that the reactor might not melt through the containment; hence a reliable ECCS is considered vital to the safety of high-powered nuclear reactors.

I reviewed these questions in my 1970 talk. At the beginning of this year the Commission instituted hearings to review the operating limits placed on reactors and on the ECCS. These limits are intended to ensure that under all credible situations a reactor meltdown could not occur.

Several members of the ORNL staff have participated in these long and arduous hearings: W. B. Cottrell, P. L. Rittenhouse, D. O. Hobson, C. G. Lawson, D. B. Trauger. In the course of the hearings, our experimental observations have been examined in excruciating detail by both intervenors and vendors. On the whole, the ORNL findings have admirably survived this almost unprecedented scrutiny. For example, the observation of Rittenhouse and Hobson that zirconium embrittles significantly even at temperatures below 2300°F if it is kept at such temperatures long enough is now accepted; and our old findings that channels can be blocked by swelling of fuel elements after blowdown will, I believe, be given weight in the revised criteria. Of particular importance has been the work of a special ORNL task force, headed by R. B. Briggs, which has combed over the 20,000 pages of testimony to help the AEC regulatory staff prepare supplemental testimony based on information brought out during the hearings.

Our participation in the ECCS hearings raises the question of whether the Laboratory, as an institution, can arrive at a consensus on technical matters as complex as those required to analyze the events that follow a loss-of-coolant accident. This question obviously does not have an unequivocal yes-or-no answer. The guiding approach to answering such questions is honesty. Where differences of opinion on technical matters remain within the Laboratory, we must acknowledge these differences and point them out to our sponsors. ORNL consists of individuals: though management can, and must, recognize that not all opinions can be given equal weight, I think we must use sparingly the power to pronounce institutional — as opposed to individual — judgments.

The ECCS hearings have just been closed. Each of the parties to the proceeding will now summarize its position, an environmental impact statement will be incorporated in the record, and the complete record of the hearing will be presented to the Commission for final decision concerning the criteria.

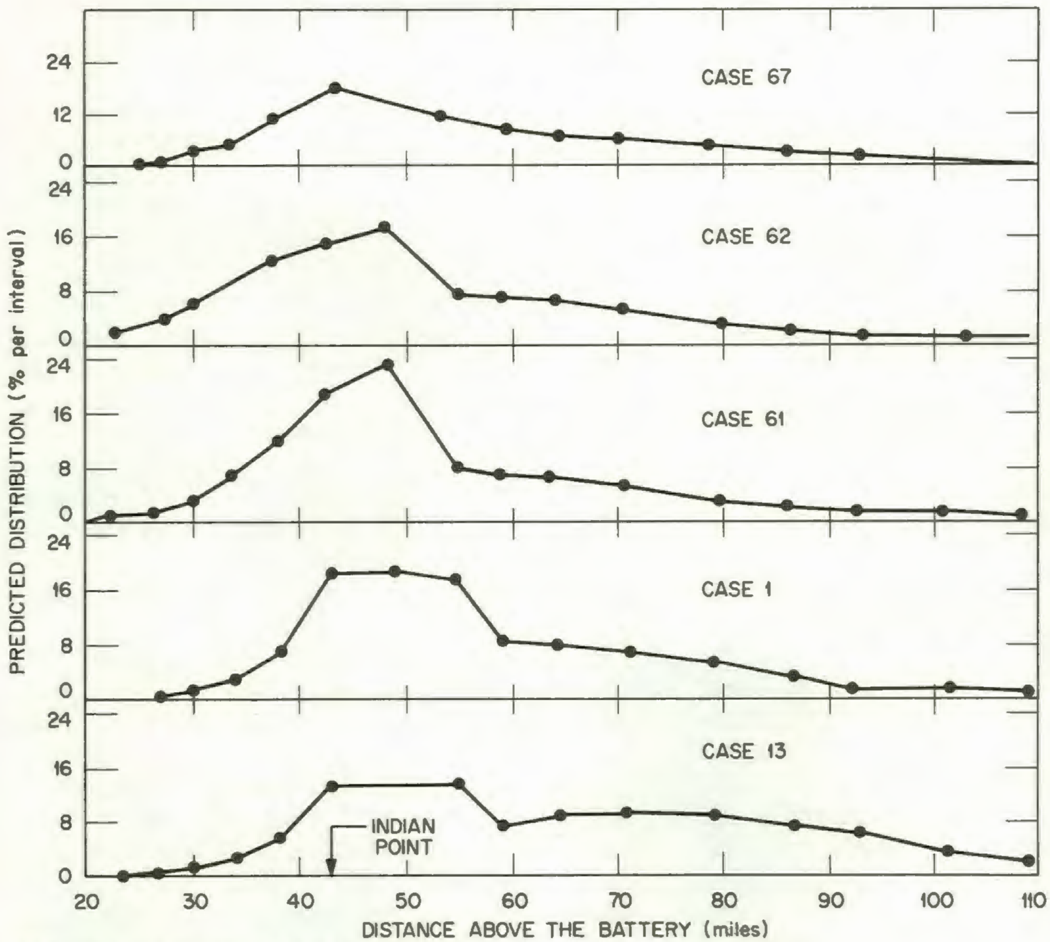
Environmental Impact Statements

The second of the year's activities fraught with great public implication is the preparation of environmental impact statements for reactors. We now have approximately 70 people serving as an extension of the AEC regulatory staff working on these statements; they have completed 13 statements and are working on 11 others. Our budget for this activity during FY-73 is $\$2.7 \times 10^6$. ORNL has acquired a reputation for preparing careful and detailed impact statements. They have embodied in full measure both the spirit and the letter of the National Environmental Policy Act (NEPA). One of our statements (Indian Point-2) prompted Anthony Roisman, an attorney for the Environmental Defense Fund, to say: "The AEC has taken on responsibility [under the National Environmental Policy Act] and has acted responsibly. There is no doubt that the AEC is now doing the best job of any federal agency in implementing NEPA."

Of the environmental impact statements we have prepared, the Indian Point-2 statement has had the most consequence. The issue was joined when C. P. Goodyear, from the Environmental Sciences Division, noticed that the area around Indian Point on the Hudson is used as a spawning ground for striped bass. The concentration of young striped bass in the Hudson peaks noticeably in this area. The larvae, being poor swimmers, are easily entrained in the intake water conduits and are destroyed. Altogether, Goodyear estimates that 30—50 percent of the young striped bass would be killed each year at Indian Point-2, and that this could lead to a corresponding reduction of the adult population of these fish within eight years. The environmental impact statement therefore recommends ". . . that the applicant consider the incorporation of a closed-cycle cooling system . . . by July 1973. After approval of this system by the AEC, it should be installed for operation no later than January 1978."

The installation of cooling towers at Indian Point might cost as much as $\$182 \times 10^6$ over the plant lifetime. Thus a recommendation to install them can be made only after the most serious and searching review of available data. ORNL and the AEC regulatory staff have studied the question from several angles, and the result seems incontrovertible: the striped bass like to spawn around Indian Point, and therefore a power plant in that vicinity is likely to cause serious damage to this species.

It now appears that our work on environmental impact statements will continue for a long time. Moreover, as the Commission's interests go beyond



Predicted distribution of larval striped bass in the Hudson River, from field observations and computer model estimates.

nuclear energy — in accordance with a 1971 amendment to the Atomic Energy Act — I should think it not unreasonable to expect our expertise to be utilized in examining the environmental impact of other energy systems.

Waste Repository

The third ORNL activity that has received much public attention is the Salt Waste Repository Project. Last year I reported concerns voiced by the State of Kansas over proposed use of the Lyons mine. These concerns have not diminished, and the AEC has now announced that for the present, radioactive wastes will be solidified and stored in above-ground concrete vaults. In the meantime, we are examining salt formations outside Kansas: there appears to be a very attractive salt deposit in southeastern New Mexico. This salt, also dating from Permian times, is 3000–4000 feet thick. Unlike the Kansas area, there are few man-made penetrations, and there is no hydraulic mining in the vicinity as was the case in Kansas.

As for the scientific validity of disposal in salt, we have found nothing during the year that shakes our belief in the basic soundness of the idea. Stored energy, diffusion of radionuclides, heat distribution in the salt, evolution of radiolytic gases — every one of these questions is being examined in detail by the project; thus far nothing has turned up that would pose a real problem. The main uncertainty — the plugging of man-made holes — is being actively pursued by our consultants.

The waste disposal question looms more and more importantly as our commitment to nuclear energy grows. There are some critics who now insist that we must turn away from nuclear energy until we have a clearly resolved way of dealing with radioactive wastes. My response to this extreme view continues to be that we do have acceptable ways of handling these wastes: either by storage in vaults or by disposal in salt. To be sure, vault storage requires active surveillance that we can hardly guarantee over the thousands of years the wastes remain dangerous. Salt still looks like an entirely feasible site for long-term storage, and one that requires minimal surveillance. It is perhaps reassuring that West Germany has come to the same conclusion: low-level wastes now are being stored in a salt mine in West Germany, and plans for storing high-level wastes in salt are going ahead there.

Energy

The energy crisis, which became quite apparent last year, has deepened. One result is that everyone wants a piece of the energy action. In the 92nd Congress there were 18 congressional committees, 189 congressional publications, and 338 bills introduced dealing with energy. Though there is much milling about, my impression is that all of the studies, symposia, and committee reports present much the same overall conclusions.

These conclusions were well summarized by the Cornell-NSF Workshop on Energy and the Environment held in February. I mention this study partly because one of the panels (on Technological Options) was organized with the help of Roger Carlsmith and involved several ORNLers or ORNL alumni, and partly because the conclusions of this and similar studies will almost surely affect the future directions of ORNL.

Two technological developments were seen as central: clean energy from coal (either by gasification or by liquefaction); and nuclear energy, particularly the breeder. [To be sure, the panel urged that alternatives to the Liquid-Metal Fast Breeder Reactor (LMFBR) be kept viable, but this is, in the larger sense, a detail.] What relief we get from our energy crisis will come, within the next 20 years, from coal and uranium. On these two points most everyone now seems to agree; and it is gratifying to see that coal people and uranium people are talking to each other constructively and sympathetically.

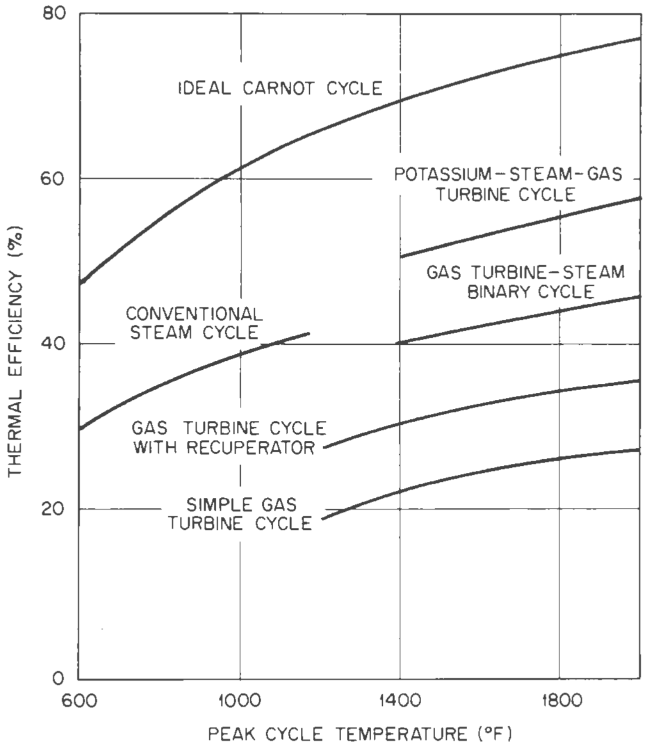
In a quite different category of feasibility and immediacy are the other potentially large energy sources — geothermal, solar, controlled fusion. In a much lower category, largely because they represent such relatively small energy sources, are wind, tides, ocean thermal gradients, renewable organic fuels, garbage. The NSF workshop also devoted some attention to reduction in demand for energy, a matter that is now receiving attention in many quarters. Thus the study focused attention both on the supply and the demand aspects of the energy crisis.

Most, but not all, of what we do on energy at ORNL is an attempt to increase supply by various technological options and devices. But we are also examining the demand side of the picture. Under our NSF-RANN program, J. C. Moyers has found that, if we were to insulate our homes 20 percent above FHA standards, we could decrease energy consumption for space heating 20 percent; or that we could double the efficiency of air conditioners at very little cost penalty; and an economic analysis by T. J. Tyrrell and Duane Chapman suggests that a one percent increase in price of residential electricity would eventually reduce demand by about 1.3 percent.

Turning to supply, I mention first clean energy from coal. Thus far we have not done very much more than try to become educated. We have requested and hope to receive from the AEC $150,000 to review the current technologies of liquid and gaseous fuels from coal. Natural gas is the ideal fuel for residential heating and many other uses because it is clean and cheap. It is projected that by 1985 there will be a shortage of 17 trillion SCF per year, which is about two-thirds of our present consumption. Thus, one of the big challenges for the U.S. in the next 25 years will be to build a substitute natural-gas industry using coal or lignite as the raw material. Coal liquefaction will be another important challenge, because here we are talking about getting adequate supplies of liquid fuel, all of which we now get from petroleum. But it is also estimated that by 1985 we could be importing 56 percent of our oil supply, which would seriously strain our balance of trade.

We have also received $360,000 from NSF-RANN to begin a more serious examination of the potassium vapor cycle. A. P. Fraas and his associates have operated small turbines on K vapor as part of the early attempts to develop auxiliary power for space; and for many years Fraas has urged that a relatively straightforward way to 55 percent thermal efficiency would be to use boiling potassium as a topping cycle. This seems to have been an idea that came before its time; but now we have money to do preliminary work.

As for solar energy, ORNL is engaged in two studies. First, we have as part of our NSF work



Comparisons of thermal efficiency among different power cycles.

tried to decide for ourselves just how much large solar energy power plants that embody the Meinel selective absorption films might cost. Our answer — $3000 per kilowatt for the first plant, perhaps $1200 per kilowatt for later plants — is not too reassuring. At $1200 per kilowatt, power would be generated for about 2.5¢ per kilowatt-hour. Now nuclear power from light-water reactors would cost 2.5¢ per kilowatt-hour only if the price of uranium went up to $260 per pound; and at this price the amount of uranium is very large indeed. Thus we now look upon solar energy as a long-term backup which would be needed only if, for some reason other than *economics*, nuclear energy should prove to be unacceptable.

There is another approach which deserves mention — the use of solar energy to enhance biological production of hydrogen or methane. Some thinking along these lines is being done at ORNL, particularly by G. D. Novelli and Kurt Kraus, but our ideas are still in a rather rudimentary stage.

Another important study is devoted to the use of hydrogen as a means of storing or transporting energy. This is again an old idea that we first proposed about 10 years ago when we were studying agro-industrial complexes. J. W. Michel headed a task force this year that studied H_2 and other synthetic secondary fuels for the AEC and the Office of Science and Technology. From studies such as these, one gets the impression that *eventually* hydrogen will be our main secondary fuel. When this will happen, of course, no one can predict.

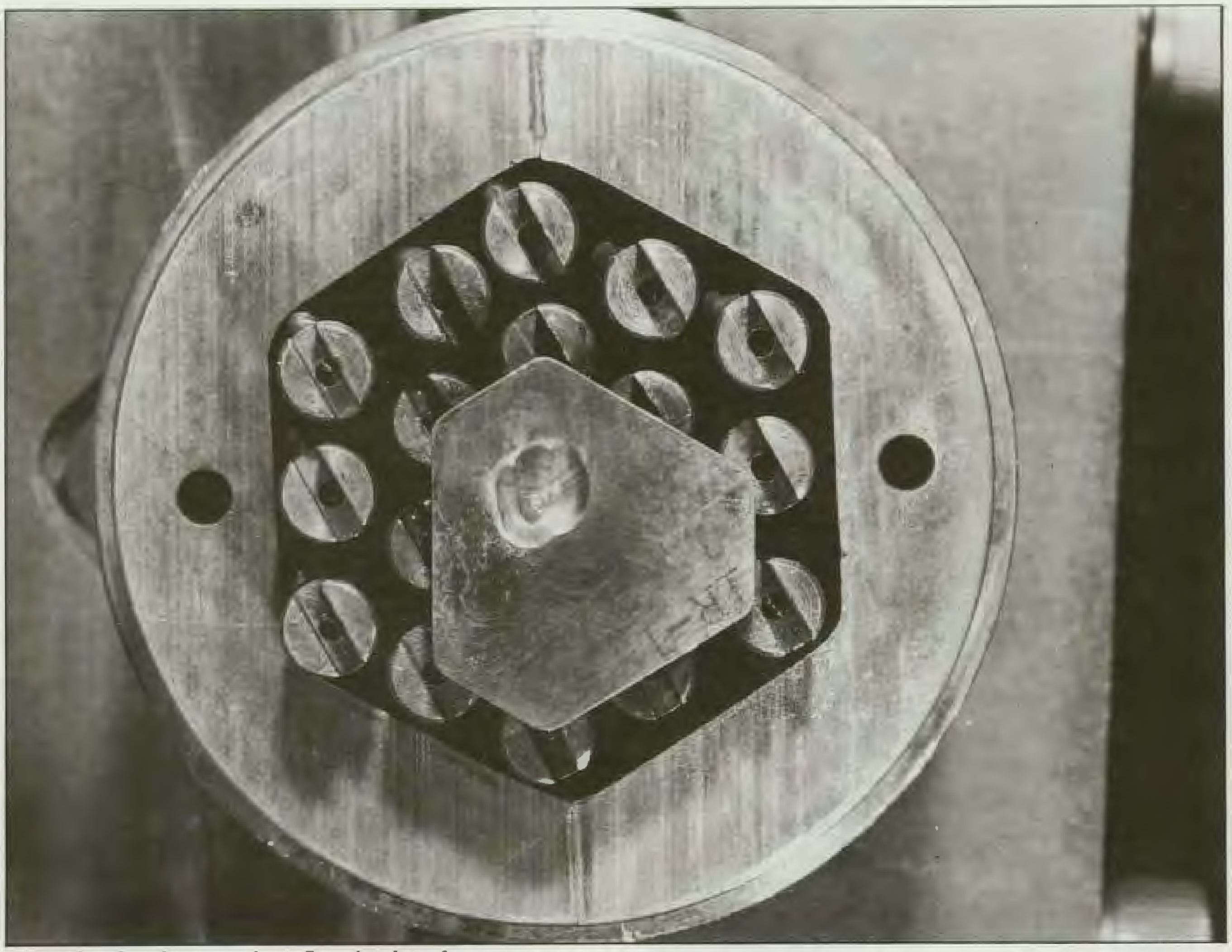
Both solar and geothermal energy represent very large resources of relatively low-grade heat. Using this heat efficiently for generating electricity has always been awkward. I am pleased therefore that ORNL, under AEC auspices, has begun to explore the use of ammonia as a bottoming cycle, possibly for a geothermal plant, or even a conventional plant, since the use of a bottoming cycle might diminish the release of waste heat.

Thus we see glimmerings of activity in many aspects of nonnuclear energy: energy demand, coal, hydrogen, transportation of energy, topping and bottoming cycles. What we are doing now is relatively little, but I would venture to predict that bigger things will come. The AEC has organized, in its Division of Applied Technology, a department devoted to General Energy Development under former ORNLer J. C. Bresee. Whether — as the press has speculated — the AEC will in fact become very heavily involved in all aspects of energy, I do not know. Whether or not this happens, I would point out that in many ways ORNL is beautifully situated to play a large role in energy. The skills we have developed under the auspices of various agencies — ranging from social aspects of energy demand to production of hydrogen and power plant siting, from biological utilization of solar energy to superconducting transmission — represent a powerful scientific resource. I can hardly believe that these potentialities will be overlooked when responsibilities for research in nonnuclear energy are assigned.

Liquid-Metal Fast Breeder Reactor (LMFBR)

I shall be brief in summarizing some of what we have done in reactor development.

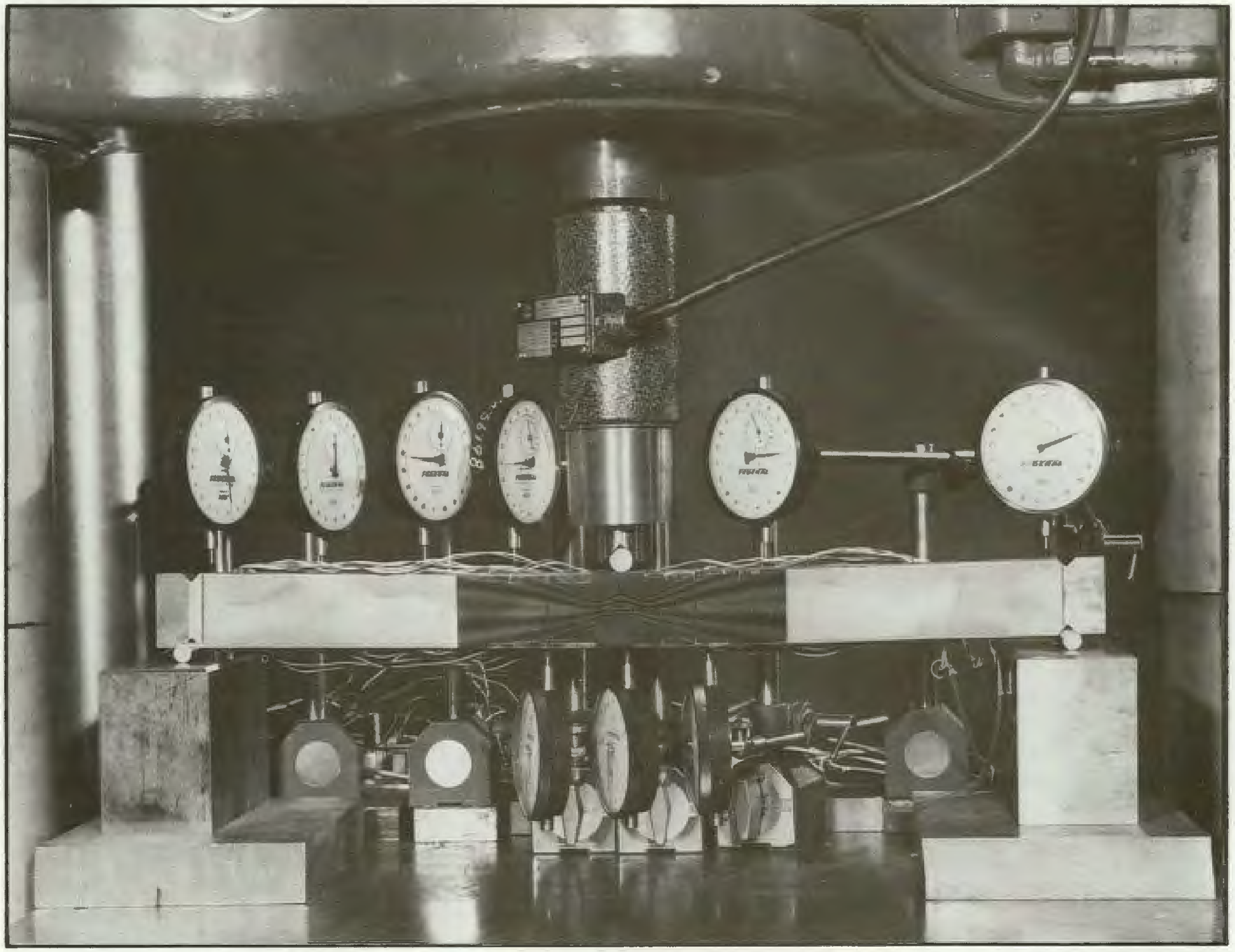
Our largest reactor effort continues to be in support of the LMFBR, with emphasis on the Fast-Flux Test Facility (FFTF) and the first U.S. demonstration plant, which is to be built in Oak



Obstacle placed on coolant flow intake of FFTF fuel assembly mockup to simulate exaggerated condition of LMFBR coolant blockage. No significant temperature rise resulted.

Ridge. I can mention only three of our accomplishments.

One of the very important questions that people ask about sodium-cooled fast breeders is: "What happens if the coolant flow is blocked inadvertently, as happened at the Fermi reactor?" To answer this and related questions of safety, R. E. MacPherson and M. H. Fontana have constructed a large sodium loop in which LMFBR fuel subassemblies are simulated with electric heaters. The system was first run in unblocked condition, and yielded data on flow and temperature useful for design of the FFTF. The flow was then purposely blocked by an obstacle four times larger than could conceivably negotiate the flow paths in the coolant entrance region of an FFTF subassembly. Because there is so much bypass flow, no temperature in the system rose significantly. This experiment thus suggests that, at least for inlet blockage caused by obstacles of which one can



Deflection test performed at room temperature on cantilevered beam of proposed structural material for LMFBR.

reasonably conceive, there is little danger of meltdown of an LMFBR.

The FFTF is a very complex metallic structure that operates at high temperature. It is therefore subject to thermal stress and creep to a degree almost beyond what engineers have encountered hitherto. W. L. Greenstreet, J. M. Corum, H. C. McCurdy, G. D. Whitman, and their colleagues have developed reliable high-temperature structural design methods that are having great impact on the whole LMFBR program. They have demonstrated experimentally that their predictions do represent the essential features of the elastic-plastic and creep behavior of simple stainless steel structures under complex loading conditions. Tests at 1200°F on simply supported rectangular beams have been completed, and experiments are in progress on circular flat plates. With the information derived from these tests, it is now possible for the first time to assess with confidence the adequacy of

FFTF component designs and to develop methods for improving designs for the demonstration plant.

Because of our expertise in the field of high-temperature materials, a team of ORNL metallurgists headed by P. Patriarca has assumed the key national role in the development and evaluation of materials, fabrication techniques, and nondestructive testing methods for the LMFBR demonstration plant steam generator and intermediate heat exchangers. In addition to substantial in-house development work, this role involves close liaison with and coordination of the efforts of the several potential industrial producers of these components.

I can but mention by title other areas of the LMFBR where we have worked this year: fuel cycle, high-temperature thermometry, criticality measurement techniques, and fast-neutron cross sections.

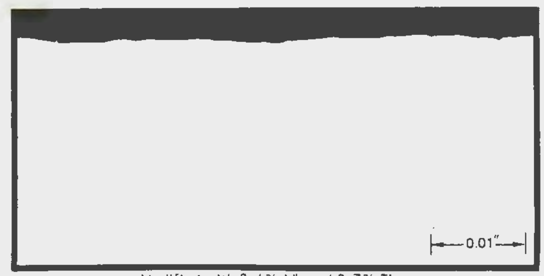
Molten-Salt Breeder Reactor (MSBR)

The molten-salt program has made important technical progress during the year. It now appears almost certain that the surface cracking of Hastelloy N observed when we dismantled the MSRE was caused by the fission product tellurium. But H. E. McCoy, aided by J. H. Shaffer, R. E. Gehlbach, and R. E. Clausing, seems to be well on the road to a fix for this unpleasantness. Particularly hopeful is the observation that several modifications of Hastelloy N that confer immunity from radiation embrittlement seem at the same time to cure the tellurium cracking disease. This may be one of those rare cases where nature is working for us: a single additive, titanium, may cure two serious deficiencies of Hastelloy N.

Progress also can be reported on the containment of tritium in molten-salt reactors. R. A. Strehlow and H. C. Savage have very recently shown that Incoloy-800 (an alloy of nickel, iron, and chromium widely used in steam generators) readily forms an oxide film which markedly reduces the permeability of the metal to tritium. It seems likely that a similar film can be produced and retained in a molten-salt reactor steam generator. If so, the film should decrease tritium permeability by at least a thousandfold, and tritium release from a molten-salt breeder could be restricted to tolerable limits.

The MSBR program is under serious scrutiny. The Commission earlier this year was invited by the Joint Committee on Atomic Energy to review

Standard



Modified with 2.6% Nb and 0.7% Ti

Two alloys of Hastelloy N after exposure to 5 × 10^{17} atoms/cm^2 for 100 hours at 700°C, deformed at 25°C.

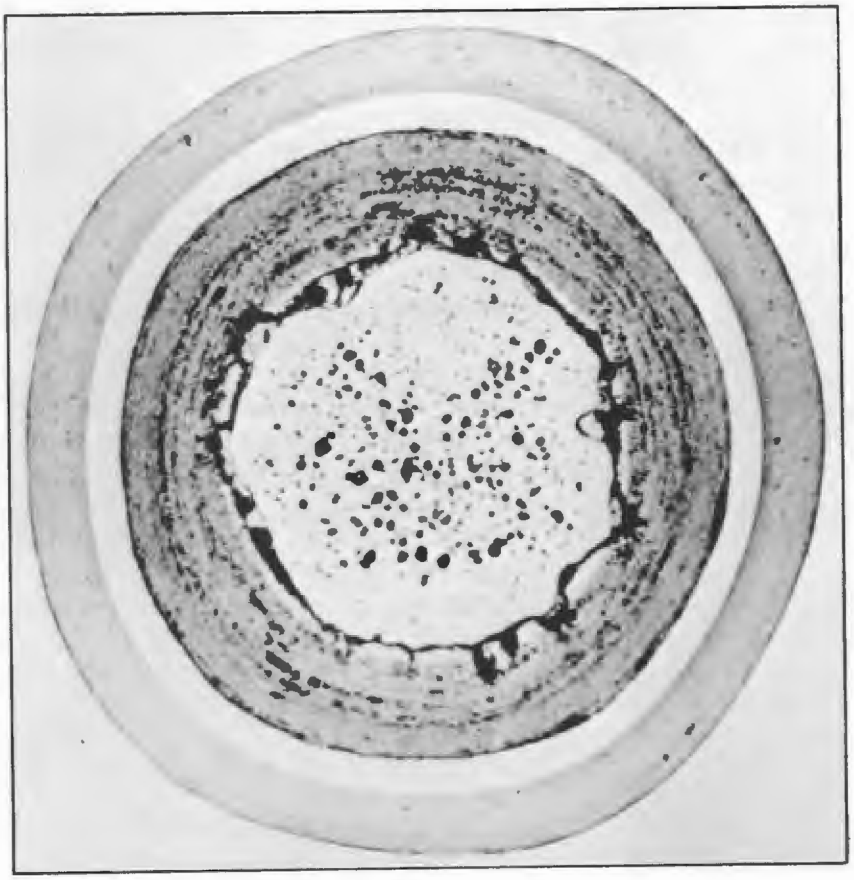
the project with a view to deciding its future. In anticipation of this review, the Laboratory prepared a detailed technical assessment of the status of the MSBR program. This 416-page study is a model of responsible and knowledgeable technical analysis. Our recommendations to the Commission are summarized in the following statement: ". . . we believe an MSBR program should proceed in three steps:

1) Continuation and some expansion of the present effort to advance the technology and to demonstrate solutions to several technical problems.
2) After several years, if the outcome of Step 1 is encouraging, construction of a molten-salt breeder experiment by the AEC to obtain a conclusive test of the features of the concept.
3) Finally, if the results of Step 2 are favorable, scaleup by industry to full-size commercial breeder reactors."

As of the moment, the final verdict hangs in the balance.

Gas-Cooled Reactor (GCR)

Perhaps the big event in reactor development this year has been the emergence of the high-temperature gas-cooled reactor as a serious commercial type. Gulf General Atomic has sold six large HTGRs totaling 5400 MWE, with the first



FAST FLUENCE: 8.3×10^{21} neutrons/cm^2
BURNUP: 25% FIMA
TEMPERATURE: 1150°C (average)
1375°C (maximum)

Triso-coated fuel particle, designed for the Fort St. Vrain reactor, after full irradiation in HFIR. Note the densification of the buffer carbon layer, the formation of fission gas bubbles in the kernel, and the integrity of the coating.

1160-MWE plant to start in 1979. Support for our gas-cooled reactor work is increasing, and now amounts to $4.5 million for FY-1973.

Testing of fuel rods is an important part of our fuel development program, performed in cooperation with GGA. The first successful performance of Fort St. Vrain reactor fuel, made in production equipment and irradiated under FSVR design conditions, was carried out this year in the HFIR.

The ability to fabricate fuel economically is also very important. W. P. Eatherly and J. D. Sease are developing improved fabrication processes with the desired technical and economic features. One process involves continuous extrusion; the other, termed slug injection, involves warm pressing a matrix slug into a close-packed bed of coated particles. Both methods appear attractive for remote fabrication applications.

Controlled Fusion

Last year at this time ORMAK was just starting its low-field trials. Since then it has given successful operation when cooled to liquid-nitrogen temperatures and is operating essentially at its design field of 25 kilogauss. Despite a variety of start-up difficulties, the desired plasma information has been obtained. Three distinct plasma regimes have been identified, and they can be produced at will. Of these, one is "best"; in this regime, with 190,000 amperes of plasma current circulating around the torus, the average plasma density is measured as 3×10^{13} electrons per cubic centimeter, the electron temperature is 500 eV (5×10^6 °C), the ion temperature is at least 300 eV (3×10^6 °C), and the pulse length is 100 milliseconds.

The critical product, peak density times mean particle confinement time, is 2×10^{11}. This is quite respectable for Tokamaks (the goal is 10^{14}), and ORMAK has checked empirical scaling laws that had indicated that a fat, compact torus is more promising than an extended, skinny one.

A major shutdown of ORMAK is planned for March. At this time, two neutral atom injectors will be added to heat the ions to about 1 to 2 keV, which will be well into the so-called "collisionless regime." In this regime, the average ion will go completely around the torus several times between collisions with other ions. This is the regime in which a fusion reactor will have to operate, and it has not yet been reached in Tokamaks. The number of injectors (two) is significant; I said four last year, but O. B. Morgan and his colleagues, T. C. Jernigan, L. D. Stewart, and W. L. Stirling, have doubled the output, and it's clear now that only two will be sufficient. Of course, other improvements will be worked into ORMAK during the March shutdown, among them measures to purify the plasma and refinements in the laser diagnostics. Next year will be an even more significant one for Tokamaks.

Last year I mentioned also the ELMO Bumpy Torus, but merely as a concept. In the meantime, this experiment has been blessed by the CTR Standing Committee — and funded. Construction is now well along. Next year I hope to be able to report in some measure on the performance of this novel plasma confinement scheme.

The Laboratory is also involved in fusion work in other ways. A major problem is foreseen in the radiation damage that will occur in the vacuum wall of a fusion reactor. The wall will be hot, and 14-MeV neutrons, at fluxes of well over 10^{14} per cm^2 per second, will displace every atom hundreds of times, and thus induce radiation damage far more severe than is expected in a fast fission reactor.

This formidable problem is being attacked on a rather modest scale in the Physics, Metals and Ceramics, and Solid State Divisions. The 6-MV Van de Graaff is being equipped with a source of heavy ions, because a beam of vanadium ions (for example) penetrating into vanadium can produce displacements at a rate sufficient to reach ~100 per atom in a few hours, without introducing impurities. Alternatively, impurities can be introduced at will. The expectation is that, with sufficient understanding, this kind of ion-induced damage can eventually be used to predict the character of the neutron-induced damage.

Meanwhile, the metallurgists are studying alloy systems that may have inherent radiation-resistant characteristics and are irradiating them at the highest available reactor fluences. One of the alloys being studied is vanadium—20 percent titanium. The work by Kenneth Farrell, Alan Wolfenden, and F. W. Wiffen shows the remarkable resistance of this alloy to void formation after irradiation to a fluence of 10^{22} neutrons per cm^2 at 550°C. The vanadium specimen was strewn with voids, while in the alloy specimen void formation was completely suppressed. Thus there is reason to hope that suitable alloys will be found that are indeed sufficiently radiation resistant to meet the operating conditions of a CTR device.

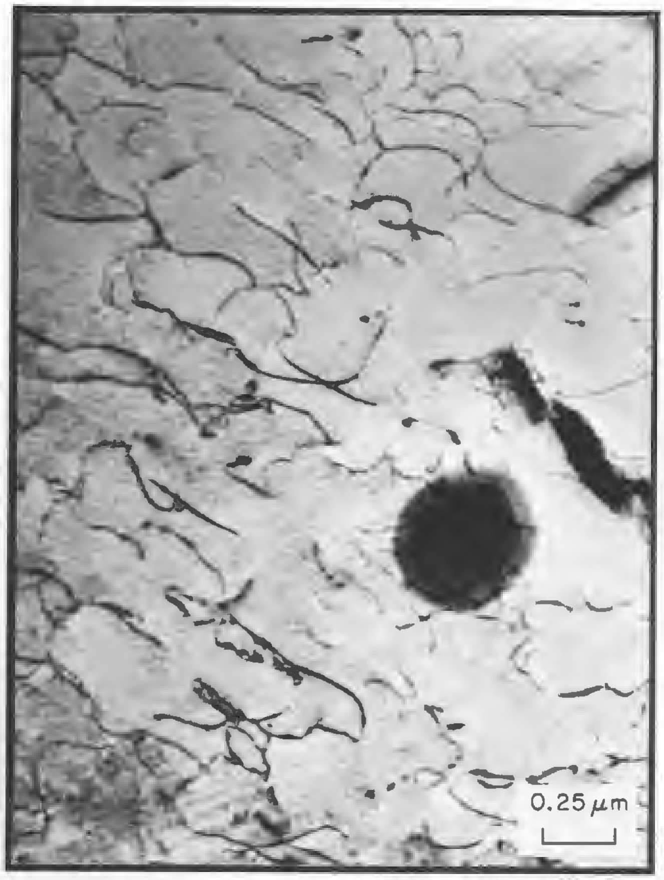
This is the kind of information that will be vital when the plasma experts finally get their plasmas under control, and the fusion people will be squarely (you might say) up against the wall.

Biomedical Sciences

1972 has been filled with much excitement for our biomedical sciences. Everyone in Oak Ridge has heard of BCG; but perhaps everyone does not realize that the significance of M. G. Hanna's findings that BCG could cause regression of certain guinea pig tumors does not lie in this fact alone. Regression of some tumors by BCG is not in itself new. Rather, it lies in the observation that BCG apparently mobilizes scavenger cells (histiocytes) that engulf and destroy the tumor in a hitherto unsuspected fashion.

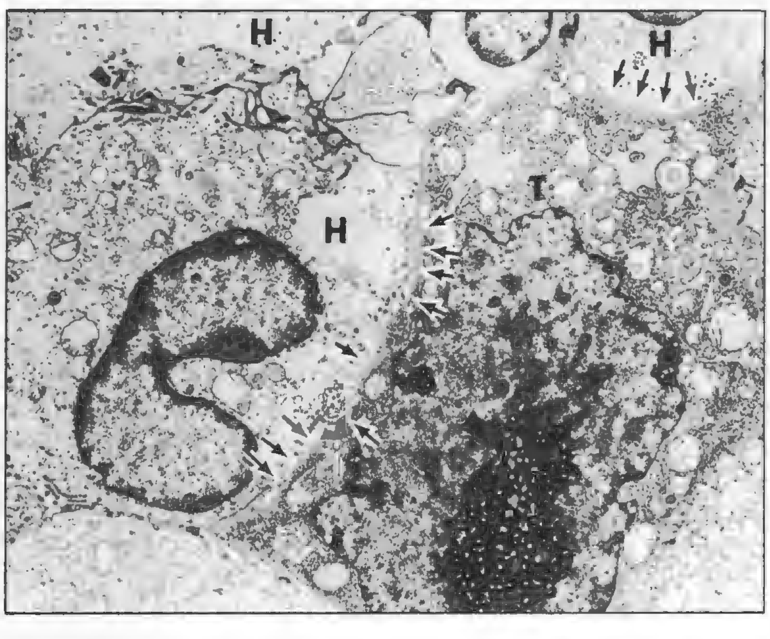
Again, the frozen mouse embryos of David G. Whittingham, Peter Mazur, and S. P. Leibo are well known; the mice grown from them have graced the front cover of *Science*. What may not be so widely known is the apparently immediate practical consequence of this very clever technique. Cattle breeders have for some time been implanting embryos in foster mothers. The embryos have been stored in the wombs of female rabbits; these "biological thermos bottles," being small, could be transported to the foster mother conveniently. Unfortunately, the cattle embryos survive in this foreign environment only a few days. If the new embryo freezing technique can be applied to cattle, it may revolutionize this industry by making it possible to preserve embryos from highly desirable animals indefinitely.

VANADIUM



V–20% Ti

Effect of neutron irradiation on vanadium and titanium-modified vanadium, showing the absence of voids in the latter.



The mechanism of BCG is to cause certain scavenger cells (histiocytes, H) to engulf and destroy tumor cells, T.

We have made important progress in our attempts to quantify the biological effects of low-level radiation on man. First, J. G. Brewen and R. J. Preston have compared, *in vitro*, the sensitivity of human and mouse chromosomes to damage by radiation. They find, for example, that a given dose of radiation causes equal numbers of deletions in mouse and man. These experiments are important because most estimates of genetic damage in man derive from experiments performed on mice. Their experiments suggest a way of translating findings on mice to estimates of hazard to man.

I mention also the experiments of J. B. Storer and his colleagues on the effects of relatively low-level radiation on life shortening and induction of tumors in mice. Storer has come up with two unexpected findings: first, that below 50 rems there is no statistically significant evidence of life shortening; and second, that above 50 rems radiation induces certain very specific tumors; and it is these, rather than a generalized syndrome, that shorten the life span of mice.

I turn now to four Washington developments that may have important bearing on our biomedical work. First, the Laboratory continues to participate, with the University of Tennessee, UT Memorial Hospital, and the Oak Ridge Associated Universities, in planning a cancer center in the Knoxville—Oak Ridge area. As part of the National Cancer Act, 15 such centers are to be established. It is premature to say whether such a center will be set up here, though NCI has granted UT $185,000 to lay out preliminary plans.

Second, the Division of Biological and Environmental Research (DBER) has begun to address the question of how the work in biomedical sciences of the AEC should respond to the Commission's broadened nonnuclear energy mission. Several members of the ORNL staff helped identify relevant areas of research. These included biological side effects of effluents from nonnuclear energy systems and biological methods of producing energy.

Third, the Health Services and Mental Health Administration (HSMHA) sent a team to ORNL in November to assess the possibility of ORNL's expanding what it is doing in improving the delivery of health care. This is a natural outgrowth of the many notable successes of the MAN Program, such as the GeMSAEC, the body fluid analyzers, and the medical scintillometers. This unique collaboration between chemical engineers and biomedical scientists has impressed HSMHA, and I would hope that by next year we will be well launched in an active collaboration.

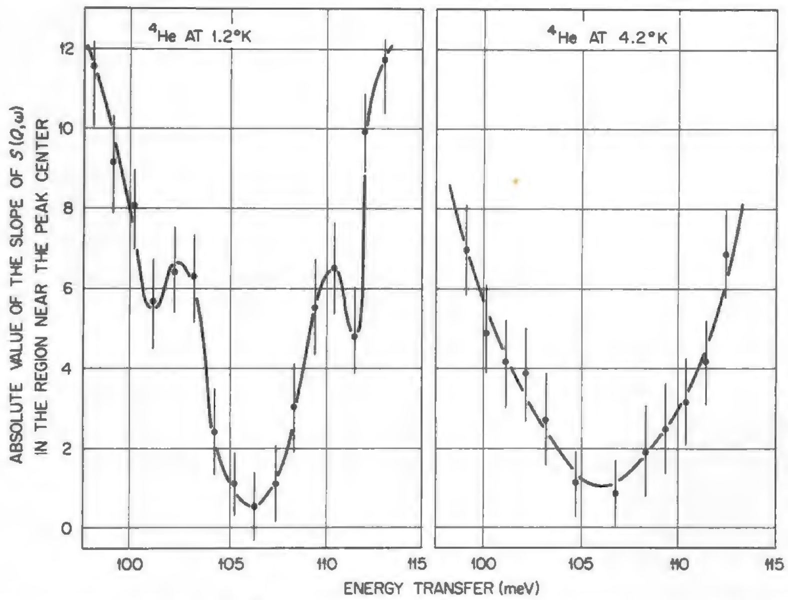
Finally, I mention that we have received important encouragement from the Commission to go ahead with a new building for the Environmental Sciences Division. Though money for the building has not yet been appropriated, I judge the probability of the project's ultimately going ahead to be very good. This must be taken, in these austere times, as an important recognition by the Commission of the power and competence of S. I. Auerbach's environmental sciences team.

Basic Physical Sciences

This year has seen more than its share of very beautiful findings in the basic physical sciences; unfortunately, I can mention but a few. H. A. Mook and M. K. Wilkinson have undertaken to determine, by the scattering of very slow neutrons, what fraction of the ^{4}He atoms in liquid helium at 1.2°K are "condensed" — that is, behave as a collective, interacting solid rather than as individual atoms. Neutrons scattered from the condensed atoms lose no energy, whereas those scattered from freely moving atoms transfer some of their energy by elastic collision. Thus by observing the number of neutrons scattered without energy loss, one can determine the degree of condensation. This was a difficult measurement and required, even at the HFIR with its extremely high flux, five months to collect the data. Quantitatively, a two percent condensation was found; this is considerably lower than the 6 to 25 percent predicted by theory, and poses an important dilemma for the theory of quantum liquid ^{4}He.

In nuclear physics I mention two items — first, the very beautiful elucidation of the asymmetry in fission worked out by H. W. Schmitt, Ulrich Mosel, and M. H. Mustafa, and the wrap-up of the neutron dipole experiment.

Why fission should be asymmetric in some elements and symmetric in others has always been a mystery. The answer has come as a kind of culmination of the work in the Fission Physics Group, and is a result of a study of the potential energy associated with the separating system. The development of the nuclear shell effects in the two fission fragments as they are formed is shown in the results of these studies. I shall not try to describe the details of these calculations — except to say that the theory predicts that ^{236}U fissions



Evidence of Bose-Einstein condensation in liquid helium is shown by the extra curves in the distribution curve at 1.2°K (left), whereas none occurs at 4.2°K (right), when no condensation is expected.

asymmetrically, ^{210}Po symmetrically, and that these predictions are confirmed by experiment.

The measurement of the electric dipole moment of the neutron has been going on at ORNL under P. D. Miller's guidance for about ten years. This year the experiment was wrapped up. The final result is that if the neutron does have in it the equivalent of a positive and a negative electron separated by a small distance, then this distance must be less than 10^{-23} cm. This is far below most of the theoretical estimates. It is the shortest distance or, more accurately, the shortest upper limit to a distance that science has ever measured.

Let me speculate on the future of the basic physical sciences at ORNL. A central issue is the fate of our proposal for a National Heavy-Ion Laboratory (NHL). We have prepared, under P. H. Stelson's guidance, an updated proposal for this \$25,000,000 project. We continue to believe that a TU tandem or ORIC injecting into a large sector-focusing cyclotron is a properly conservative approach that will guarantee 10 MeV per nucleon for very heavy ions. Our revised proposal points out the many scientific as well as technological opportunities that such a device would open. These possibilities go far beyond the production of super-heavy elements, exciting as these would be. But we believe we have been realistic: the super-heavies still remain a long shot, and we do not base our case for an NHL on their existence or nonexistence.

What are the probabilities that this project will indeed come to fruition? On the positive side is the very strong support NHL has received in the NAS report *Physics in Perspective,* which states that: "Internationally this area of nuclear physics is attracting the greatest interest, effort, and support. Involving the interactions of large pieces of nuclear matter, this research makes accessible, for the first time, entirely new modes of nuclear motion and dynamics and permits study of more familiar phenomena in entirely new regions of angular momentum and other parameters. It also makes accessible new nuclear species — through moving away from the nuclear valley of stability to isotopes as yet unknown and proceeding upward along this valley to possible new super-transuranic elements. Quite apart from the very great intrinsic interest in these new areas, there are potential applications for these new species in medicine, power generation, and national defense. Initiated in the United States, this work is being pursued vigorously by the Soviet Union, Germany, France, and other western European countries, and indeed in all the major nuclear centers around the world, with a wide variety of major accelerator facilities newly under construction. Unless the U.S. community can move rapidly toward the establishment of a competitive national facility, we will cease to have a significant role in this important field." I have reason to believe that this view is having influence within the Commission, the OST, and possibly even the OMB.

However, these positive signs must be placed in perspective; money for the physical sciences is short, and it is still impossible to predict whether funding for NHL will be available in FY-74.

Future Direction

Last year I described this as a time of transition for ORNL. I believe we are continuing to see changes; perhaps we see the shape of the new developments a little more clearly than we did last year.

The transition is focusing more sharply on *energy*. In this, I may mistake my own predilection and desire for what is really happening. But the signs, to my mind, are unmistakable: ORNL is becoming involved broadly with energy.

Though this trend is still tentative and uncertain, we have been taking steps to anticipate it. Some of these steps I have already mentioned. Others include a full-fledged self-analysis of our position in basic physical sciences — the so-called Basic Physical Sciences Assessment Council (BaPSAC). We initiated this study late last year on the general ground that, after doing basic research in physical science for some 25 years, it would be advisable to review our whole position. The BaPSAC study is not complete; but what we have done represents an illuminating analysis of physical science research at ORNL. One of the sub-panels of BaPSAC, headed by M. K. Wilkinson, is asking what areas of basic research would most appropriately underlie our ventures into nonnuclear energy. Obviously, this is a tough question; yet I believe it is most important that we have addressed it.

It ill becomes me, at this time when ORNL is once again suffering through a budget squeeze, to display a facile and shallow optimism. Nevertheless, I am strongly impressed by what ORNL can contribute to the resolution of the country's energy crisis. All of us are awaiting the President's message on energy. Once this is delivered, I would hope that we can see the Government's role in energy research and development clarified and consolidated; and I would venture to predict that this role will be considerably expanded. Should this indeed happen, then I would hope that the virtues and talents in the many sciences and technologies underlying energy that I perceive us to have would be equally evident to those who are given responsibility for carrying out the new energy initiative. It will then be up to us, by our technical achievement, to establish ourselves as a powerful force in research in energy. This is a challenge that I hope the coming year will present to us: I have no doubt that, faced with this challenge, we will convert it into an opportunity for strengthening both our institution and our society.

Take A Number....

By V. R. R. Uppuluri

DON'T KICK THE TIRES

At any exhibition of calculating machines, one can find calculators, both machine and human, of all sizes. Some of the new pocket-size machines have keys for finding exponentials and square roots. I watched a number of people trying out these machines at a recent exhibit at ORNL, and was reminded for some reason of the classic test for selecting a used car: the perfunctory kick on the tire. I'm not sure whether looking under the hood is a better check or not, but it seems to be more satisfying to some prospective buyers. The following tests for calculating machines may come closer to this latter method of selection than such tire-kicking maneuvers as finding the 32nd power of 2:

Take the number 2. Find its square root, 1.41421, and add 2 (=3.41421). Take the square root of this (=1.84776) and add 2 (=3.84776). If you continue these operations of taking square root and adding 2, you will ultimately end up with 2, since the sequence converges to 2 fairly rapidly.

Another illustration, using exponentials: Take any number X_0. Change its sign and find $X_1 = \exp(-X_0)$. Change its sign and repeat, $X_2 = \exp(-X_1)$. Continuing to repeat this process, you will arrive at the solution of $X = \exp(-X)$, which is 0.567143.

In both of these tests, it may be seen that different calculators take differing numbers of steps to arrive at stability. Which one you choose, however, you must decide for yourself.

SPELL AND TURN

When I was a child, my friends and I had a card trick that amused us and with which we sought to amaze others. It involved a particular numerical progression. After secretly stacking a deck of 13 cards of a single suit, the trickster would solemnly count off by removing the top card and placing it on the bottom of the deck, at the same time spelling the number of the card he prepared to summon. "O," he would say, moving the top card to the bottom, and he would repeat the process with each letter, "N, E." The next top card, when revealed, proved indeed to be the ace. Then he would start again, spelling "T, W, O," after which he would turn the deuce; spelling THREE and turning the three, etc., until all of the cards of the suit had been placed in order in a pile. All that was needed to perform this simple trick was to know how to stack the deck in advance.

The necessary order happens to be 3, 8, 7, A, Q, 6, 4, 2, J, K, 10, 9, 5, from top to bottom face down. This order supposes that after TEN, one spells JACK and QUEEN. In this way the 13 cards have been removed in their natural order. That is to say that for a given spelling of the 13 cards, the unique initial order specified above gives rise to the natural order of the removed cards. For spellings in different languages, of course, one can construct the appropriate initial arrangements leading to the natural order of the removed cards.

I have used some of these ideas in generating permutations of n distinct objects in a systematic manner. A formula for arriving at the required order, however, although it presents a number of complications, probably could be achieved.

Where do they GO --OUR POISONS?

By William Fulkerson

Bill Fulkerson, coordinator for the Laboratory's NSF/RANN program on Ecology and Analysis of Trace Contaminants, came to ORNL in 1962 from Rice University, where he had just earned a Ph.D. in chemical engineering. After eight years in the Metals and Ceramics Division, he joined the 1970 Summer Environmental Project, going on to active involvement in the ORNL-NSF Environmental Program. He served as leader of the Material Resources and Recycling Team until its curtailment last year, and the work that is described here has led directly to the current program concerning trace contaminants in the environment.

Elizabeth Peelle, sociologist, has recently undertaken a study of social effects to be included in the Environmental Impact Statement for the Mendocino (California) nuclear reactor.

ONE CONCERN OF THE ORNL-NSF Environmental Program is what we call socially optimum resource management, in which three goals seem important: reasonable material affluence, pollution control, and conservation. The decentralized, self-regulating market system accomplishes the pursuit of material wealth fairly effectively, although the distribution is not always optimum. The increasingly important goal of pollution abatement (and also to some extent conservation) is largely external to the market; hence, the relative priorities among the three goals must be set through our social, political, and legal institutions. We see our work as helping with the national efforts to assess the problems and the opportunities entailed in achieving the pollution control and conservation goals. We help by developing, synthesizing, and broadly communicating information to clarify the options available to society.

The proper assessment of these problems requires an interdisciplinary effort, and so we tried to build a team involving at least some social science in addition to a variety of physical and biological sciences and engineering. As one might expect of an ORNL team, the social scientific manpower was quite small. In fact it was not exclusively manpower at all but included sociologist Elizabeth Peelle, consulting for the group on a half-time basis. Elizabeth made some very valuable contributions to the team. In addition to her study on forest management and land use conflicts, she also helped us to see very early the underlying assumption in our approach, which was that society should try to work toward some sort of dynamic equilibrium or quasi-steady state with regard to resource management. Implied here is obviously a population steady state as well.

The Ideal Resource Situation

Thanks to Hal Goeller's work, we can at least give a reasonable scenario of what this steady state could be like relative to materials. Assuming that population can be made to level off [see box] and that energy is available for not much more cost than it is today, then sufficient nonrenewable resources will probably also be available. Our bases for this optimism are, first, that a large number of very important elements are infinitely available at present or near present costs and, secondly, that most material functions are substitutable. For the elements with limited availability at present or near present extraction costs, supplies will still be adequate provided recycling is practiced efficiently and provided more plentiful materials can be substituted when the uses of these elements are dissipative. The question is, Will these conservation steps be implemented with sufficient haste (as steady state is approached) to avoid catastrophic shortages? The normal market forces may not always provide the required incentives or long-range outlook; therefore, a continuing national effort in assessment is necessary to establish the research priorities or to otherwise tweak the system into conservation actions. However, it is comforting to note that the present cost of nonfuel mineral resources amounts to only about 1% of the U.S. GNP, so significant price increases can undoubtedly be afforded over the long run.

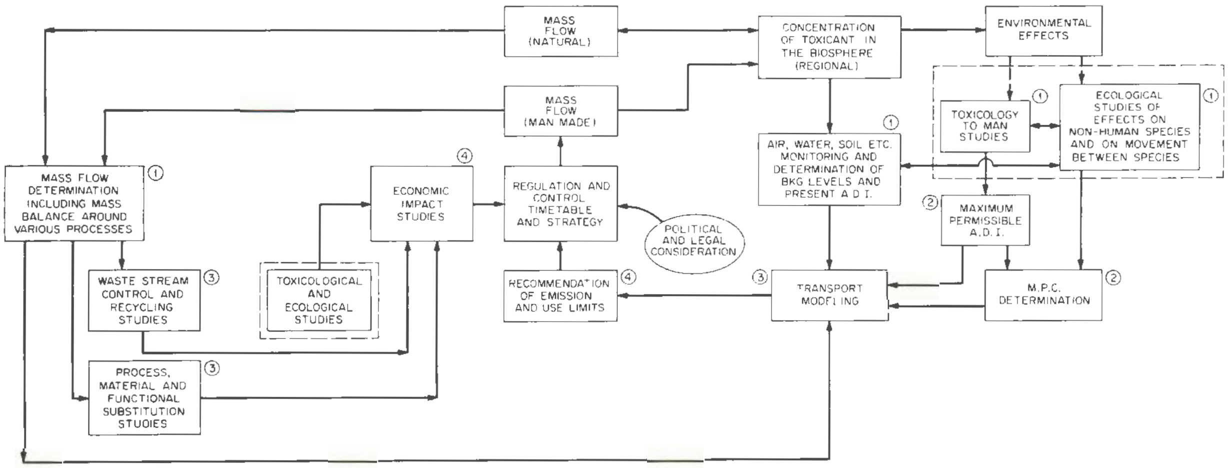
There may be some critical cases, and Goeller's study indicates what we should look for. Certain uses of some elements are essential, or at least very important to civilization. If substitutes are not found for these uses, and if the element in question is limited in supply, then we are in trouble. Goeller cites as an example phosphorus, essential to life and the only one of the major elements in commercial fertilizer not in infinite supply at near current costs. If the population level is allowed to rise to a very high number, say fifteen billion or more, then the cost of fertilizer may increase over the next century to an unacceptably high figure and/or the ecological damages of phosphate runoff may become intolerable. Both eventualities should result in moving to a smaller population. Of course, the population can decrease to a point at which sufficient phosphorus for agriculture could be supplied by organic farming.

Working closely with Fulkerson are chemical engineer Hal Goeller and economist Gurmukh Gill.

Energy Expenditures on Metals

In our substitution and recycle world we can foresee that the infinitely available metals of magnesium, aluminum, and iron will be used much more widely in place of other, scarcer materials; therefore, we inquired about energy costs (mine to ingot) of producing these metals from lower grade ores compared with those currently used. MIT Practice School students Jean Claude Bravard and Charles Portal did the initial work under Goeller's direction, and NSF presidential intern H. B. Flora II expanded on the original theme. The energy expenditure for magnesium from seawater is the highest, being about 91,000 kWhr/ton, a cost which will remain constant or perhaps drop slightly with technological advances in the future. Aluminum from high-grade bauxite ore (50% Al_2O_3) costs about 51,000 kWhr/ton in equivalent coal energy (assuming a 40% efficiency in converting coal or other fossil fuels to electricity). Going to high-alumina clays or anorthosite will require 30 to 40% more energy. For the production of pig iron, changing from high-grade hematite ore to much more available magnetic taconites will require only about 12% more energy, but to go to iron laterites may require a 63% increase from 3200 to 5200 kWhr/ton.

"Leveling off" implies that man has learned to control his numbers. Once this essential lesson is mastered, then population could obviously be adjusted to any desired level, up or down. Thus, as usual, the key problem to solve is social, not technical.



Flowsheet showing theoretical control of toxic materials in the environment.

The energy required to produce these three metals now consumes about 3% of the total U.S. energy budget. In the future this percentage might double or triple because of lower grade ores and increased demand via substitution. Such growth can be slowed down by increasing recycle. We estimate that reasonably high-purity aluminum scrap can be recycled (melted) for an energy expenditure only 2 to 5% of that required to win the metal from high-grade bauxite ore.

The Environment and Materials Management

Our research into the problems of pollution abatement has taken two directions: first, waste management, emphasizing recycling; second, toxic elements. I will merely mention the various waste management activities, because these stories need to be described in their own right, and I cannot do them justice here. Josh Johnson and his colleagues in the Water Research Program have been very successful in applying dynamic membrane hyperfiltration (reverse osmosis) to such important industrial nasties as kraft paper mill bleaching wastes and textile mill dyeing wastes. Experiments on actual wastes indicate that by tailor-making the membranes one can either clean the water to a degree suitable for discharge or provide sufficient treatment for recycling of the water and, in some cases, for recovery of chemical constituents as well. In addition, Frank Snyder and I have been studying the feasibility of a regional system of solid waste management for the greater Knoxville-Chattanooga area. This system, which we call Wasteplex, would emphasize waste utilization and recycling on a large scale with the anticipation that the economies of scale can offset transportation cost of getting the wastes of a 29-county area to a central site. We recognize here the fact that if capital-intensive waste recycling is to be practical for that half of the U.S. population living outside metropolitan areas of 500,000 or more, then regional waste management will be required.

Controlling Toxic Elements

In the Fall 1971 issue of the ORNL *Review*, Robin Wallace described his trials and tribulations in putting together the best selling report *Mercury in the Environment — The Human Element*. We have now written a sequel which we call *Cadmium — The Dissipated Element*. In doing this work we have had to think long and hard about controlling the man-induced flow of toxic elements into the environment. Economic reasoning gives a theoretical model through cost-benefit analysis for applying controls. First, for any pollution source you assess the costs of abatement as a function of the level of cleanup of the waste streams involved; then, you measure the damages in terms of biological as well as aesthetic impacts as a function of the levels of emissions and assign dollar values to the damages. The optimum level of abatement is that for which the cost for removing one more unit of toxic element discharge is equal to the benefit of that removal in damages avoided. Any greater degree of control would result in costs exceeding benefits, and any lesser degree, the opposite. Control is achieved by setting emission standards or taxes or by offering economic inducements.

The trouble with this model is that, in the case of toxic elements, we do not have the information required to make such an analysis. Well, that's just fine. It means we all have a lot of useful research to do, which will, no doubt, keep many of us busy for years to come. We will get ecologists, biologists, epidemiologists, and sociologists busy on quantifying the damages. Armed with this intelligence, the economists can assign costs. Engineers can spend their time figuring out the price of abatement as a function of alternative technological strategies. (This, by the way, may be the most cost-effective research, but as an engineer, I am biased.) In all seriousness, we should try to do much of this work. Some of it is being done in the NSF-founded RANN program Ecology and Analysis of Trace Contaminants and the joint Purdue-ORNL project Environmental Aspects of Cadmium. However, we should recognize at the outset that an entirely satisfactory answer may never be found. As Alvin Weinberg has suggested, the determination of long-term low-level effects characteristic of environmental toxic element contamination will be very difficult to quantify: the determination may be "trans-scientific." For example, there is evidence that cadmium accumulation may cause kidney damage after 50 years of exposure to dietary intake levels which are only a factor of two or less above normal, but actually quantifying the increased probability of kidney damage as a function of cadmium dose rate could take years of research. In addition, there is the problem of placing a dollar value on these damages. What is the value of human life? Or, if you don't happen to be people oriented, how would you set a price on the life of a bald eagle? Or, more appropriately, perhaps, how do you put a value on the *last two* bald eagles? These may be "trans-economic" questions.

For these reasons I am not sure cost-benefit analysis will ever be an effective way to establish toxic element control policy. So, while working on obtaining the knowledge for a cost-benefit analysis I would suggest two additional activities which I believe would help enormously toward developing a rational, albeit somewhat arbitrary, toxic element control policy.

First, I think the nation should consider an accountability system for toxic elements in order to determine the quantity of material flow in society, and thereby better identify potential sources of environmental loss. The Environmental Protection Agency is now obtaining some emission data specific to toxic elements through the reporting system of the Refuse Act of 1899 and through the provisions of the Clean Air Act. Further information should be forthcoming as a result of the adoption of the amendments to the Federal Water Pollution Control Act (called the National Water Quality Standards Act) recently enacted by Congress over presidential veto. To me, the effectiveness of this reporting system could be enhanced greatly if mass balance data on toxic elements were required of industry — not just emission data.

My second suggestion relates to the fact that toxic elements tend to accumulate in the environment near emission sources. Over long periods of time, soils and sediments can become contaminated enough to poison man's food supply. Natural recovery, after pollution is stopped, may take a very long time. It seems to me that a potentially important control signal could be the rate of increase of toxic element concentrations in the soil and sediment sinks as well as in the air, the water, and various biota. We could arbitrarily establish a dictum that, regardless of the damage, we don't want toxic element concentrations to increase with time faster than some determined value. We increase controls until the rate is slowed below that value. The work necessary to determine what controls are needed (over and above the accountability system mentioned above) is periodic monitoring of levels in the environment. Some periodic monitoring of air and water is already practiced by EPA, the Geological Survey, and other agencies, but for the case of toxic elements this needs to be expanded to (at least) soils, sediments, and plants near the major sources of emission. Since we are talking, usually, about very low levels (i.e., parts per billion to parts per million), chemical analysis is always a question. For this reason I would suggest that a National Environmental Specimen Bank be established in which specimens collected periodically around the country would be stored. In this way, as analytical techniques improve, retrospective studies of one toxic element or another could be made to determine the rates of change. Also, such a specimen bank would be very useful in the future evaluation of materials not now suspected of being environmentally damaging. Such a banking system could be administered by the National Bureau of Standards or by EPA, and specimen collection and storage might be set up on a regional basis and be entrusted to land-grant or other universities.

BOOKS

By Alex Zucker

Same Old Stuff

Only One Earth, by Barbara Ward and René Dubos. W. W. Norton & Co., New York (1972). 225 + xxv pages, $6.00.

WHAT A SUPREMELY INTELLIGENT BOOK! And what an enormous area the authors attempt to cover. Nothing short of a description of the earth, man's effect on it, and the consequences and perils involved in the interaction between man and the environment. *Only One Earth* was commissioned for distribution to participants of the United Nations Conference on the Human Environment held in Stockholm last summer. It was written by Barbara Ward and René Dubos. Ward is a renowned British economist who specializes in international development. Dubos is an eminent pathologist and bacteriologist whose energies lately have been turned to environmental problems. The purpose of the book was to provide each member of the Stockholm Conference with a clear and reasoned account of mankind's environmental problems, to give a brief historical treatment about how these problems have come to be, what their likely consequences are, and what we can do about them.

Not unexpectedly, we find the spotlight focused on those areas of environmental concern which are international in scope, either because they involve interactions between nations, or because they exhibit a large degree of commonality among nations. The book is a result of unprecedented eclecticism. Over 150 consultants in various fields, and from nearly all the concerned nations, were invited to comment on the draft of the book, and, as the authors say, their comments were given thorough and impartial consideration. It must have cost the authors a great deal of effort to digest so much material, to include so wide a variety of views, and still to produce a book that is clear, that presents a unified position, and, above all, that is so eminently literate.

The breadth of Ward and Dubos' perspective is awesome indeed. The book begins with a brief history of the planet; it next describes the development of commercial and industrial human activity and then goes on to treat in some detail the problems connected with energy: "In the last analysis, everything is energy ... ." The usual pollution problems are cataloged: air pollution, pesticides, water pollution, solid waste disposal, problems of urban growth, etc. The presentation is everywhere honest. No problem is dismissed as trivial, no easy solution is peddled to the unwary. In just over 200 pages the uninitiated reader will have acquired a first acquaintance with the more prominent features of the total environmental problem. For those who have been here before, the book is a little disappointing; nothing really new is presented, nothing arrests the mind except the felicity of style. In almost primer fashion the authors repeatedly mention cost-benefit calculations and the need to internalize external costs. Overpopulation is plangently deplored; preservation of the natural environment is advocated. The overall impression of the book is that the authors want to ease a potentially hostile reader into environmental consciousness by rational argument and by skillful marshaling of facts. They don't want to excite him and they don't want to arouse latent antagonisms. The book is never hysterical, never desperate. In fact, and perhaps surprisingly, the authors, after presenting a particularly thorny environmental problem, almost always go on to say that technological and sociological solutions exist, that they are essentially at hand, that their costs are not insuperable, and that mankind, if it will only think clearly and act reasonably, can live happily ever after on this planet. An unexpected mixture of Cassandra and Candide.

Much of this is admirable and indeed essential for a book designed to produce in Stockholm an atmosphere conducive to a certain measure of unity among the nations. The conflicts are sharp. In this case the adversaries are not aligned along the east-west axis but rather in the north-south direction. Most of the developed nations are in the north; much of the environmental damage is caused by overindustrialization of northern lands. The southern countries feel very strongly that they are being told by the north to sacrifice economic development in favor of preservation of the environment. Quite rightly, they feel that they should not be the only ones to bear the burden of the cost of such action. The north-south dichotomy goes deeper, however. People in moderate climates in Europe, North America, and Asia see nature as a friend and a source of inspiration, full of spiritual value. Nature, in European and Far-Eastern poetry, is second only to love. A walk in the forest or the contemplation of a lake arouses in us emotions of calm and beauty. But we must bear in mind that these reactions are by no means universal. To inhabitants of harsh climates, nature is more often an enemy than a friend. In the southern climates the sun is harsh, the jungle treacherous, and the vast desert areas uninhabitable and hostile. It is not surprising if the drive to preserve the environment in the south is tempered by skepticism, or if an airport ranks higher on the value scale than a swamp.

There are other problems. Population densities in the south are such that even great technological successes carry with them the shadow of impossible social consequences. For example, the green revolution has at least temporarily averted starvation in many parts of the world. But the green revolution means that food must be produced efficiently with heavy application of fertilizers and pesticides, and with as much machinery as possible on relatively small acreage. It benefits few and throws many on the dole. True, a nation like India can now feed itself, at least in times of normal rainfall, but the new agriculture raises the real possibility that half the Indian population may in twenty years be on welfare. No nation can tolerate the conditions under which half its population is out of work, and the authors clearly point out that the first need is to balance the requirements of employment with those of productivity. While every human being is entitled to the essentials of life, he is also entitled to feel that he is a valued human being. To this end a person must be employed in a useful way. A society whose sole concern is increased productivity will fail if it does not consider the equally important human value of universal useful employment.

The book unfortunately avoids making policy recommendations. It doesn't, for example, discuss the relative merits of effluent charges, pollution permits, or special taxation as alternative methods for controlling air and water pollution. It doesn't dwell on any particular international environmental problem such as the pollution of the Baltic, the possible degradation of the Mediterranean, or the unfettered exploitation of hydropower in Africa. It is understandable that Ward and Dubos try to avoid irritating anyone. But the net result is too bland for my taste. The book not only eschews recommendations, it also avoids listing the options; and this is its greatest failing.

The authors have chosen to paint with a muted palette as they try to convince the reader, by reason and through an accumulation of an enormous amount of data, "that each man has two countries: his own and the planet Earth." The fact that the Stockholm Conference was a success and that we are now witnessing the parturition of an environmental arm of the United Nations indicate that the book may have played an important and successful role, and that Ward and Dubos have chosen the right strategy for their particular audience.

RUSSIAN DIARY:

Impressions from a Brief Visit

By W. L. Marshall

William L. Marshall, Jr. came to the Laboratory in 1949 with a Ph.D. in physical-organic chemistry fresh-garnered from Ohio State. At ORNL he joined in the study of high-temperature aqueous solution chemistry, motivated at the time by interest in aqueous homogeneous power reactors. His many publications based on his continuing study of aqueous electrolytes have attracted international attention. He spent a year at the University of Amsterdam on a Guggenheim Fellowship in 1956–1957, and has delivered papers to a large number of meetings throughout the world. Attending one such international conference in England as this issue goes to press, Marshall's last foreign travel was as invited plenary lecturer before an international meeting on geochemistry in Moscow. His report of that trip was so readable, and his enthusiasm for his Russian colleagues so infectious, that we were moved to ask him for a full account of that visit to the U.S.S.R.

LAST YEAR I was honored by being invited to deliver an opening lecture on aqueous electrolyte behavior before the First International Geochemical Congress, meeting in Moscow. It was held at the Moscow M. V. Lomonosov State University. This Congress of 1500 delegates was composed chiefly of Russians, with about 200 foreign visitors from Eastern bloc countries and elsewhere, including approximately 15 geochemists from the U.S.A. It was well organized, even to the extent that Russian stamps honoring the Congress were issued. A broad range of good quality research papers was presented.

To make this trip was an enlightening experience, and I was allowed the opportunity not only to meet and discuss science personally with many Russian colleagues, with whom I have had continuing correspondence, but to gain a few fleeting impressions of people and customs in Moscow and Leningrad. Certainly, a great thrill and honor came from the invitation of the eminent academician A. P. Vinogradov to do research at his institute. In this article I hope to convey some of my personal experiences during a brief, but most busy, eight days in Russia.

Arrival in Moscow

On my arrival in Moscow I was pleasantly surprised by the reception. Geochemists B. N. Ryzhenko, S. D. Malinin, and A. V. Ivanov met me at the airport, bypassed any delay through customs, took me in a chauffeured car to the Hotel Leningradskaya, handled the check-in, and did not leave until all arrangements were completed. Dr. Ryzhenko was assigned by Vinogradov, Russia's foremost geochemist, to be my aide for the Congress. Ryzhenko provided admirable assistance, obtained chauffeured cars for visits to various laboratories, and finally took me to the airport on the last day.

First Day at the University

Since the Congress did not start officially until Tuesday, I had planned to rest and do some sight-seeing on Monday. However, after arrival I discovered that I was to give an opening plenary lecture. To satisfy the interpreters I had to spend several hours on Monday at the University writing the talk. I managed to do this under difficult circumstances, since various Russian geochemists approached me to discuss our ORNL researches. Also, I was asked to write some material for the Russian press, which I did. Later that day I was able to do some sight-seeing with Drs. Ryzhenko and Malinin before attending an elegant reception for special guests of the Congress at the Prague Restaurant. The tables were laid abundantly with wines, vodka, red and black caviar, meats, delicacies, and, later, desserts. I returned to my hotel at 10:00 PM in time to review my lecture for the following morning.

Opening of the Congress

On Tuesday morning the opening speakers were invited to a social in the president's room at the University starting at 9:00 AM. A large buffet of caviar, meats, cookies, wine, and coffee was offered, making for an amiable informality among the speakers, who included Vinogradov, Soviet Minister of Geology A. V. Sidorenko, and Professors N. I. Khitarov, A. I. Tugarinov, and A. B. Ronov, among others. At 10:00 we filed onto the stage of the main auditorium to face the 1500 delegates and to present the opening talks. I felt pleased with my own presentation, with the presentations of the other speakers listed above, and with the subsequent invitation from Minister Sidorenko to visit with him at the Ministry on the following morning.

After a hurried lunch I was asked to participate in a conference before 30 members of the press, together with Khitarov and Tugarinov. We discussed the significance of the Congress, our own researches, and applications of geochemistry. That afternoon I cochaired the session on Hydrothermal Processes, and later had a round-table discussion with approximately ten physical chemists and geochemists from several laboratories. The discussion centered on our ORNL work in relation to their own studies. After a lively, friendly session, I arrived back at the hotel at 8:30 PM and had dinner with several delegates just before the hotel restaurant closed.

Meeting with Soviet Minister of Geology

On Wednesday morning Ryzhenko and the Minister of Geology's Chief of Protocol, V. N. Philippov, arrived at the Hotel Leningradskaya to take me to my appointment with Minister Sidorenko. Beforehand, his chauffeur drove us to Red Square for a little sight-seeing. Arriving at the Ministry at 10:00 AM, we were ushered into the Minister's office, where we sat at a large conference table, partaking of a small buffet of assorted cookies, coffee, and tea. There were five of us: Sidorenko, Ryzhenko, Philippov, a man from the Russian Foreign Office, and myself. This was a general session of pleasantries, lasting two hours. In addition to his government position, Sidorenko is a scientist and full member of the Soviet Academy of Sciences. He spoke only Russian, which was translated by Philippov. I started the conversation by discussing Sidorenko's plenary lecture on fossils in Precambrian rock. We then talked about our ORNL researches on high-temperature water solutions and their significances to geochemistry and to the Geochemical Congress. I introduced the subject of general science education, and we exchanged some thoughts on this topic. We next talked on progress toward international understanding and its encouragement through international conferences.

Sidorenko, lastly, discussed Lenin as a scientist. He referred to specific writings and books by Lenin, all of which were in his office library. We had a most enjoyable and friendly session, and I valued the rapport that we developed.

The Vernadsky Institute

After the visit with the Minister of Geology, Ryzhenko and I arrived at the University in time to have lunch and to learn that Vinogradov had invited me, with about twelve other foreign delegates, to visit the Vernadsky Institute of Geochemistry and Analytical Chemistry that afternoon, about a kilometer from the University. I was disappointed that I could not take the scheduled bus tour of Moscow arranged for the foreign visitors, but the very efficient, young Dr. L. N. Kogarko stated that it would not be possible, and that she would arrange a special tour for me later.

The Vernadsky Institute is in a 20-year-old university building that is typical of many throughout Western Europe. There are about 800 working people at this Institute, which has the greatest reputation in Russia for both geochemistry and analytical chemistry, and the laboratories are well equipped. Vinogradov, the Institute's director, is also a vice-president of the Soviet Academy of Sciences. During recent years he has visited the U.S.A., particularly NASA, to discuss the space programs and to present related Russian researches.

We arrived at the Institute at 1:00 PM and were ushered into Vinogradov's inner office. Coffee was served, after which we gathered around a conference table with Institute Professors Khitarov, Tugarinov, Ronov, and others. Vinogradov then detailed the organization of the Institute and the work under each professor. The visitors, who included Professors R. E. Folinsbee, F. G. Smith, D. M. Shaw, and E. M. Cameron of Canada; Y. Wyart of France; J. Konta of Czechoslovakia; I. Barnes of the U.S.A.; and H. H. Moenke of the German Democratic Republic, were then offered the choice of several tours of the Institute. We, as guests, were given essentially complete freedom during these tours. For example, I stayed with one group for a while, then left by myself to join another group, and later talked separately with other people in the Institute. I also visited the museum, which consisted of two rooms, one of which was a replica of Vernadsky's study.

After two hours we again assembled in the Director's office. When all were seated, Vinogradov spoke of the importance of experimental physical chemistry to geochemistry in the attainment and interpretation of properties of high-temperature aqueous electrolytes. He then gave me a personal invitation to do research at the Vernadsky Institute, an honor to which I responded with thanks. He continued with a discussion of his thoughts on the origin of craters on the moon and followed through with comments on the great value of international conferences toward increasing the understanding among scientists. After agreeing with his latter thoughts, I commented on general science education for all the population as a way toward greater understanding, to which Vinogradov responded with a smile that this was an old story.

After further exchange of comments, Folinsbee asked whether we could see the Russian lunar samples. Vinogradov promised that we would be able to see the samples later; we saw them, in fact, at the Vernadsky Institute on Friday.

Ryzhenko took me back to the hotel, and that evening I went to the ballet for performances of works by Chopin and Borodin, and also in the Russian contemporary mode, at the Bolshoi Theatre. I missed my scheduled taxi, but by quickly learning the subway system, I managed to get to my front row seat just as the ballet started.

Tour of the Kremlin

On Thursday, following a short morning session at the Congress, Ryzhenko took me to the Metropole Hotel to join a group for a tour of the Kremlin. I had assumed that a bus would take us to the Kremlin, but instead our group walked the distance, a little over a kilometer, to a particular entrance. Inside, we visited and saw the famous churches and different buildings, and the palace museum of the Kremlin that contains treasured collections of the Czars. At the end of the tour I strolled back to the Metropole Hotel to meet Ryzhenko.

The Moscow Power Institute

After lunch, Ryzhenko and I kept an appointment at the Moscow Power Institute, the foremost institute in Russia for training power production engineers, comprising about 10,000 students and faculty. I had asked to visit the Institute for two reasons. First, I wanted to speak with academician M. A. Styrikovich, director of the High-Temperature Institute, about the forthcoming International Conference on High-Temperature Aqueous Chemistry to be held in January at the University of Surrey in England. He and I are both members of the organizing committee. And second, I wanted to see the work there on high-temperature water-electrolyte chemistry related to steam cycle power generation. Unfortunately, Styrikovich and his wife and fellow scientist, Dr. O. I. Martynova, were in Italy for an extended stay; however, his associates were expecting me and provided a very good reception. These people included Drs. V. S. Polonsky, V. L. Menshikova, and B. P. Golubev (electrical conductances); I. S. Kurtove (solubilities); and M. I. Reznikov (liquid-vapor equilibria). After a preliminary discussion of the research programs on high-temperature steam and solutions, I toured the laboratories and spoke with the individuals concerned with particular programs. Later, we returned to the main office for coffee and cakes and a final discussion, after which I was chauffeured back to the hotel.

The Lunar Laboratory

Friday proved to be a busy day. I had been invited, with Professor E. A. Radkevich from Vladivostok, to cochair a four-hour morning session on hydrothermal equilibria. She and I alternately introduced speakers, I with an interpreter. At 11:00 AM I received a message from Vinogradov to visit him at 1:00 that afternoon to see the Russian lunar samples. Ryzhenko and I arrived on time at the Vernadsky Institute together with several other visitors. Vinogradov discussed briefly the Lunar Laboratory located within the Institute and then introduced us to Professor Sorkov, director of the Lunar Program. Dr. L. S. Tarasov, head of the lunar sampling procedures, showed us the two lunar receiving rooms. One room contained the isolation chamber, a cylindrical clean box about two meters long by one meter in diameter, fitted with six sets of rubber gloves, into which the Russian lunar samples were loaded at the site of the capsule landing. The entire chamber, containing the samples, was then brought to the Vernadsky Institute. The second room contained the polystyrene cells into which the lunar samples were placed and examined. We asked many questions; all were answered freely. The total area of these two rooms was approximately 60 square meters. Three microscopes were set up for examining the lunar samples. We returned later to Vinogradov's office for our goodbyes.

Interview for Moscow Radio

After the visit I returned to the University for a taped interview for Moscow radio to be broadcast on Sunday night. This interview lasted about 15 minutes. A girl from the press bureau translated, and the questions were similar to those asked at the press conference. In addition, I was asked about my impressions of Moscow, the people, the Congress, and so on, to which I responded favorably.

Institute of Inorganic Chemistry

Following the interview, Ryzhenko took me to the Institute of Inorganic Chemistry to visit Dr. V. M. Valyashko and associates. Valyashko is carrying out researches on the phase equilibria of salts in concentrated aqueous electrolytes at temperatures to 500°C. These studies were started about 25 years ago by Ravich and Borovaya and resulted in many pioneering papers in this field. During coffee and cookies, Valyashko told of his present studies on the system KF-LiF-H_2O at high temperatures (100–500°C). He and his colleagues then showed me the apparatus that had been used by Ravich and Borovaya for their many solid-liquid

Geochemists B. N. Ryzhenko (1.) and S. C. Malinin, who were assigned by Academician A. P. Vinogradov to smooth the details of Marshall's visit in Russia. Behind them, inside the Kremlin, rise the voluptuous outlines of St. Vasily's basilisk.

Interpreter Elena Muraveyskaya, member of the Moscow press who officiated at the author's interview on Moscow radio, and later accompanied him on his sightseeing tour of Moscow. On the far side of the Moscow canal are some of the newly constructed residential apartment buildings that are changing Moscow's skyline.

Intourist staffer who helped with travel arrangements.

phase equilibria studies with which I was quite familiar. I was, of course, interested to see this high-temperature, high-pressure equipment and was reminded of similar early apparatus of G. W. Morey in the Geophysical Laboratory of the Carnegie Institution in Washington, D.C.

Automobile Tour of Moscow

Since I had missed the Congress tour on Wednesday, I was driven around Moscow late Friday afternoon. Mrs. Elena Muraveyskaya of the Moscow press, who had acted as interpreter for me in the radio interview, together with Ryzhenko, showed me the places of greatest interest in Moscow, such as the main shopping streets, the diplomatic district, the Tretyakov Art Gallery, and the monument erected to commemorate the victory over Napoleon's armies. She also showed me the Moscow Conservatory, her favorite place in Moscow. She would not let me take a picture of her with Tchaikowsky's statue, stating with a smile that it would "disgrace" the composer. She showed me the cemetery where her uncle, President Zentrewitch of the International Oceanographic Commission, was buried; he had died the previous year. Her husband is a doctor of biochemistry. Mrs. Muraveyskaya commented that the streets would be rather bare later that evening because most Russians would be indoors watching "The Forsyte Saga," the BBC serial recently shown as well on U.S. educational television. Ryzhenko and I let her off at the International Cinema Festival for the evening movie. The following week, she and her husband would go to Bulgaria on vacation. I arrived back at the hotel just in time to be met by

V. M. Valyashko for dinner at his apartment at the University.

Family Dinner at the Valyashkos'

The invitation for dinner Friday night came from both Professor M. G. Valyashko and his son, V. M. Valyashko. Their families share a large apartment of about 120 square meters in a building attached to the main structure of the University. The two families comprise, in addition to the four adults, two small children. With two other guests, Dr. Ken Sugawara of Japan and Professor Mario Dall'Aglio of Italy, we had a delightful evening. Dr. Sugawara was secretary of the International Association of Geochemistry and Cosmochemistry, which, with the Soviet Academy of Sciences, was cosponsor of the Congress. We discussed many topics, from comparisons of life in various countries to Professor Deryagin and "polywater" (see ORNL *Review* for Winter 71). When the three of us left, the Valyashkos, as a gracious gesture, gave us each a hand-painted wooden bowl.

The Friday evening with the Valyashko families emphasized to me that a moderate number of families in Russia may be dedicated to science. For example, M. G. Valyashko, his son, and both wives all have doctoral degrees in chemistry. During the week, several scientists had casually mentioned to me that their wives, sons, or daughters were also scientists.

Leaving Moscow

On Saturday, Ryzhenko insisted on seeing me off at the airport. Since the plane to Leningrad was two hours late, he and I had some more time to discuss our mutual interests: ionization equilibria in water solutions at high temperature. I finally discovered that he considered ionization constants in units of molality, whereas our group at ORNL uses units of molarity, thus resolving our puzzle over interpretation. I left Moscow for Leningrad, where, over the weekend, I managed to see the Hermitage Museum, two performances of the Kirov Ballet (The Stone Flower and The Fountain of Bakhchisarai), as well as a performance of the opera Boris Godunov.

Some People and Observations

It was gratifying to be able to meet and talk with Russian people other than scientists. I found all of these people, met by chance, to be very friendly and helpful. Intourist, the government travel agency, operated most efficiently for me. The women attendants on my floor of the hotel were friendly and courteous and provided pleasant conversation, albeit in Russian. I had little difficulty in riding streetcars in Leningrad and in asking directions and using maps and other visual aids, although the language barrier is considerably greater than in Western Europe. As in other parts of the continent, people were quite anxious to help. I should like to summarize a few of the more interesting encounters and observations.

After the ballet in Moscow, around 10:00 PM, I walked to the National Hotel to have dinner. The restaurant was crowded but I managed to get a large table, which I suggested sharing with five Russians who were also seeking a place to sit. They had arrived earlier from Dagestan, 1600 kilometers distant, and were wrestling in the Moscow championship tournament the next day. One spoke English, a school teacher in addition to being a wrestler. I ordered a big dinner. They, having eaten earlier, ordered cognac. We had a very pleasant hour together, with much friendly discussion and "toasts to our lasting friendship." I managed to sip very little cognac, realizing the strenuousness of the next day. On leaving, the wrestlers paid for my dinner (about $4.50 equivalent) over my protests and gave me a pass for the wrestling matches which, to my regret, I was unable to use.

During the Sunday morning ballet at the Kirov Theatre in Leningrad, I sat next to a Soviet family of four who were on a month's vacation from Armenia. The husband taught English, and he and his family came to Leningrad every year to enjoy the many cultural activities. We talked at length during an intermission while walking with many others around a large circle in one chandeliered room — the exercise room! He told me that his family had emigrated a few years ago to Iran and had later returned to Armenia. They were a friendly family, and we have since corresponded.

It was interesting to observe the selling of ice cream at intermission at the Kirov Theatre. The ice cream is weighed out in a silver dish to the exact amount requested. The dish sits on a pan balance, and if too much has been added, the surplus is returned to the container. I managed to get my ice cream just before the start of the next act after waiting in a short line for most of an intermission. It was good and worth the wait.

In Leningrad I enjoyed meeting and attending a ballet with Drs. William B. and Patricia R. Harris, attorneys from Washington, D.C. He is with the U.S. Federal Power Commission, and his wife was the Ambassador to Luxembourg during the administration of President Johnson. Dr. Patricia Harris was later Chairman of the Credentials Committee for the 1972 Democratic National Convention.

Also in Leningrad I met Marc Houlihan of Palo Alto, California, a former motion picture script writer who is now writing a history of 19th Century Russia. He had arrived a few weeks earlier in Leningrad, planning to stay only two weeks, but changed his plans in order to stay three months. He appeared to know every detail of Russian ballet and music, including essentially the life history of many performers, a man of lively enthusiasms and very good company.

By coincidence, an anniversary related to the Russian Revolution was celebrated while I was in Leningrad. I watched several cruisers and submarines, with flags flying and bands playing, arriving up the Neva River for the celebration. Crowds of people were walking up and down the parks and walkways next to the river. The weather was perfect, and I managed to take a number of pictures. Later in the evening, fireworks were set off over the river.

Conclusion

As a result of these eight days, which allowed personal contacts to be made in Russia with a discipline of science unique to ORNL, we hope to maintain friendship with many Russian geochemists. Ryzhenko has already spent ten months in the U.S. at the University of California, Los Angeles, and at Pennsylvania State University. During this time he visited at ORNL for discussions on high-temperature aqueous chemistry and its relations to geochemistry. In all respects, I considered my participation in the Moscow International Geochemical Congress, and the related visits, to be highly successful.

LAB ANECDOTE

HAFNIUM-FREE ZIRCONIUM FOR NUCLEAR REACTORS

The nuclear metallurgists recognized very early that the resistance of zirconium to corrosion in high-temperature water would make it useful in water-cooled nuclear reactors. Zirconium's only drawback seemed to be its moderately high cross section for the capture of thermal neutrons. In early 1948, Herbert Pomerance, working at Clinton National Laboratory, proved that the cross section was not 3.5 barns but more nearly 0.2 barn: the higher value from an older sample was principally due to contaminant hafnium in the zirconium. An economical chemical separation of the two was needed.

All zirconium minerals contain from one to three percent hafnium. Both elements have the same valence, 4, and nearly the same ionic radius; thus they are strikingly similar in their chemical reactions. Partial separation of the two elements, through laborious fractional precipitations, had been achieved in the laboratory after discovery of hafnium in 1924 but appeared to be hopeless for large-scale economical exploitation.

What was to be the Materials Testing Reactor was designed at Oak Ridge in 1947. The uranium fuel was clad with aluminum. Physics Division Director Alvin Weinberg suggested to Captain Hyman Rickover that a zirconium-clad fuel with the MTR design would provide a nuclear reactor for submarine propulsion. Rickover pushed the proposal and found the developmental money, and many organizations were soon at work on the separation of hafnium from zirconium. The low cross section of zirconium, a fact of nature, was never restricted information. The separation of hafnium from zirconium, on the other hand, was treated like all industrial secrets and not made public. The first disclosures were made at the 1955 Atoms for Peace conference in Geneva.

The first successful separation process, one still in commercial use, was developed at the Electromagnetic Separations Plant, now Y-12. It was based on an article by Fischer and Chalybaeus of Hanover, Germany, who enriched hafnium by extraction with thiocyanic acid and ether from an aqueous solution. A small group at Y-12 under Warren Grimes in Glenn Clewett's Chemical Development Department began in May 1949 to adapt this process to a large scale. With the radiotracer ^{181}Hf and methyl isobutyl ketone in place of ether, they soon defined the process variables. U.S. Patent 2,938,769 was granted nearly eleven years later, when security restrictions on the submarine reactor were eased, to C. J. Barton, L. G. Overholser, and J. W. Ramsey. Analytical support came from Cyrus Feldman of the ORNL spectroscopic laboratory.

The next stage of development was a pilot plant, also at Y-12, under W. M. Leaders. A four-inch glass column for countercurrent extraction produced ten pounds per day of zirconium with less than 200 ppm of hafnium, about six months after the laboratory work began. Further scale-up of the process under G. A. Strasser and John Googin of the Production Division gave, in March 1950, 450 pounds per day of a product with less than 100 ppm of hafnium. The four-story-high columns were built in Building 9211 (now full of Biology laboratories), which had been erected during the war for the countercurrent extraction of uranium from laboratory and process wastes. Clarence Larson had had a hand in the design of the building originally, and now, as Superintendent of the Y-12 Plant, he supported the zirconium work.

The hafnium-free zirconium must also be freed of other chemical impurities. The research group under Warren Grimes, enlarged to include Paul Blakely and John Redman, demonstrated that precipitation of zirconium salicylate at controlled acidity gave a good product; this method was used in 1950 to prepare a 25,000-pound lot of reactor-grade zirconium. Later this procedure was supplanted by precipitation with ammonium phthalate, a more economical process because the phthalate can be recycled.

The production plant in Building 9211 continued to produce all the world's supply of pure hafnium-free zirconium. It had produced 200,000 pounds by the time, two years later, the process was turned over to private producers at the request of the AEC. The zirconium, principally in the form of Zircaloy, is today a necessary material of the nuclear Navy and of commercial nuclear power. — C. J. Barton.

to a pH in the range of 12 to 14, and the amount of said 1,3-dichloro-5,5-dimethylhydantoin being from 0.0018 to 0.54 weight percent based on the weight of 1,3-dichloro-5,5-dimethylhydantoin and water in said aqueous bleach composition.

2,938,765
PROCESS FOR THE PRODUCTION OF ALKALI-SOLUBLE COTTON TEXTILE MATERIALS
Robert M. Reinhardt and John D. Reid, New Orleans, La., assignors to the United States of America as represented by the Secretary of Agriculture
No Drawing. Filed Apr. 11, 1957, Ser. No. 652,321
3 Claims. (Cl. 8—116.2)
(Granted under Title 35, U.S. Code (1952), sec. 266)

1. A process for producing a cotton textile material, which prepared material is substantially completely soluble in 10% aqueous alkali and which prepared material retains, substantially unaltered, all the useful textile properties of the original unmodified material, comprising a mild chemical modification of the original cotton textile material to substitute therein a radical selected from the group consisting of aminoethyl and carboxymethyl to a degree of substitution of about from 0.01 to 0.1 average number of aminoethyl or carboxymethyl groups per anhydroglucose unit of the cellulose chain, and oxidation of the resulting chemically modified cotton textile material for from 1 to 5 minutes at room temperature with an aqueous solution containing about from 1 to 3 weight percent of chromic acid and about from 0.5 to 3 weight percent of oxalic acid.

2,938,766
STERILIZATION OF HOSPITAL AND PHYSICIANS' SUPPLIES
Lloyd A. Hall, Chicago, Ill., assignor to The Griffith Laboratories, Inc., Chicago, Ill., a corporation of Illinois
No Drawing. Filed Jan. 21, 1958, Ser. No. 710,198
4 Claims. (Cl. 21—55)

1. The method of sterilizing hospital and physicians' supplies of animal and vegetable origin, which comprises subjecting the material enclosed in a gas-permeable protective container therefor at a temperature in the range from 70° F. to 100° F. to a vacuum of at least 29 inches of mercury in a closed chamber for at least 45 minutes, admitting into said evacuated chamber substantially undiluted ethylene oxide gas in amount in the range from 30 to 65 pounds per 1000 cu. ft. of chamber space, thereafter subjecting the material to the action of said gas for a time in the range from one-half to four hours, then increasing the vacuum to at least 29 inches of mercury and thereby withdrawing free ethylene oxide gas, then flushing the chamber with sterile filtered dry air to establish atmospheric pressure in the chamber, and then removing from the chamber the material within its closed gas-permeable container, whereby all of the organic life in the article and within the container is killed.

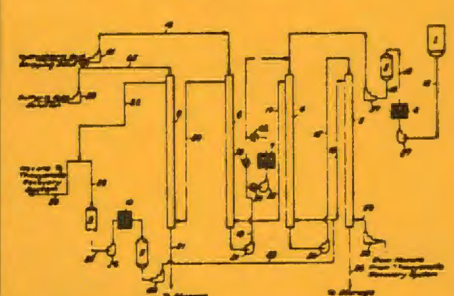
2,938,767
DISPLACEMENT METHOD FOR PREPARATION OF METAL BOROHYDRIDES
George F. Huff, Fox Chapel, and Albert D. McElroy, Evans City, Pa., assignors to Crllery Chemical Company, Pittsburgh, Pa., a corporation of Pennsylvania
No Drawing. Filed Apr. 12, 1954, Ser. No. 422,646
7 Claims. (Cl. 23—14)

1. A method of preparing metal borohydrides comprising reacting a solution of an ionic metal borohydride selected from the group consisting of sodium, potassium and lithium borohydrides in a non-aqueous ionizing solvent selected from the group consisting of polyethylene glycol di-lower alkyl ethers, lower alkyl amines, pyridine and liquid ammonia with a metal of the desired borohydride in the presence of a substantial quantity of mercury, the metal of the desired borohydride forming an amalgam less readily than the metal of said dissolved ionic borohydride, and recovering the resulting metal borohydride thus formed.

2,938,768
METHOD OF SEPARATING Pu FROM METATHESIZED BiPO$_4$ CARRIER
William J. Knox, New Haven, Conn., and Stanley G. Thompson, Richmond, Calif., assignors to the United States of America as represented by the United States Atomic Energy Commission
No Drawing. Filed May 13, 1952, Ser. No. 287,614
5 Claims. (Cl. 23—14.5)

1. A process of recovering an actinide rare earth from a bismuth hydroxide carrier precipitate which comprises washing said precipitate with an aqueous solution 0.05–0.5 N in HNO_3, whereby the transuranic polyvalent actinide rare earth is dissolved, and separating the aqueous solution from the insoluble bismuth precipitate.

2,938,769
SEPARATION OF HAFNIUM FROM ZIRCONIUM
Lyle G. Overholser, Charles J. Barton, Sr., and John W. Ramsey, Oak Ridge, Tenn., assignors to the United States of America as represented by the United States Atomic Energy Commission
Filed July 31, 1952, Ser. No. 301,902
3 Claims. (Cl. 23—23)



1. An improved solvent extraction process for effecting substantially quantitative separation of hafnium impurities from zirconium values which comprises contacting an aqueous feed solution phase containing zirconium, hafnium, and chloride values, with a methyl isobutyl ketone phase, at least one of said phases containing thiocyanate values, separating the resulting zirconium enriched aqueous phase from the resulting hafnium enriched methyl isobutyl ketone, contacting said hafnium enriched methyl isobutyl ketone with an aqueous hydrochloric acid solution, separating the resulting zirconium-containing hydrochloric acid solution from the resulting zirconium-depleted, hafnium-enriched methyl isobutyl ketone, and acidifying said feed solution with the resulting zirconium-containing hydrochloric acid solution.

2,938,770
PROCESS FOR THE PURIFICATION OF ALKALI METAL HYPOPHOSPHITE SOLUTIONS CONTAINING ALKALI METAL PHOSPHITES
René Pahud, Bex, Switzerland, assignor to La Forte Electrique S.A., Bex, Switzerland, a corporation of Switzerland
No Drawing. Filed June 2, 1958, Ser. No. 739,976
Claims priority, application Switzerland June 18, 1957
6 Claims. (Cl. 23—107)

1. A process for the purification of an aqueous alkali metal hypophosphite solution containing an alkali metal

Page from Official Gazette for 1960 on which the Oak Ridgers' invention for removing the hafnium from zirconium is described.

OAK RIDGE NATIONAL LABORATORY *REVIEW*

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