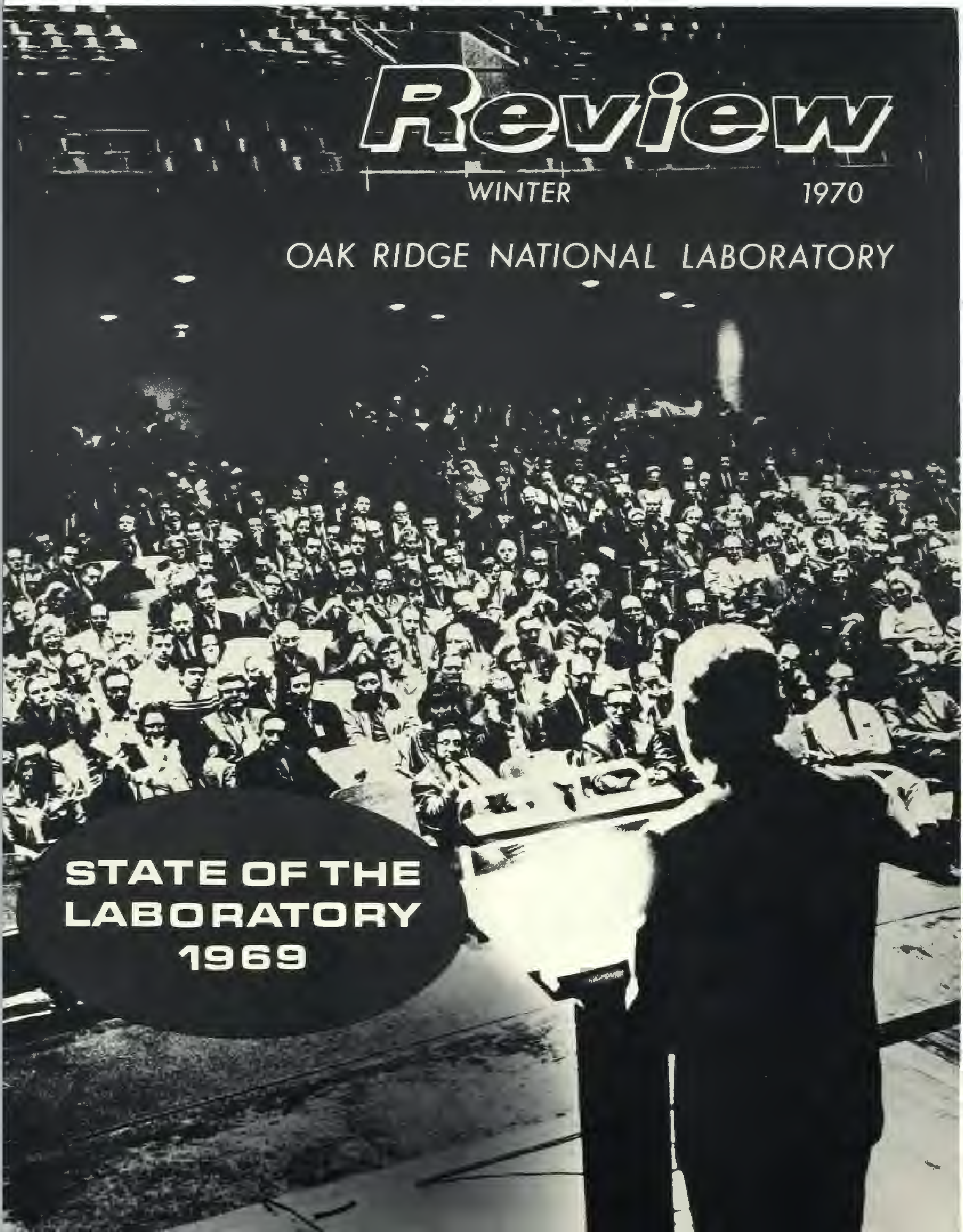
Review

WINTER 1970

OAK RIDGE NATIONAL LABORATORY



STATE OF THE LABORATORY 1969

Review

OAK RIDGE NATIONAL LABORATORY

VOLUME 3, NUMBER 3 **WINTER 1970**

THE COVER: This year's State of the Laboratory message carried the additional burden of interpreting the significance to ORNL's future of the severe financial retrenchments imposed in 1969. Laboratory Director Weinberg cited ORNL's history of technical successes as he examined the role of the national laboratory in the search for solutions to the problems of environmental deterioration. The full text begins on page 1.

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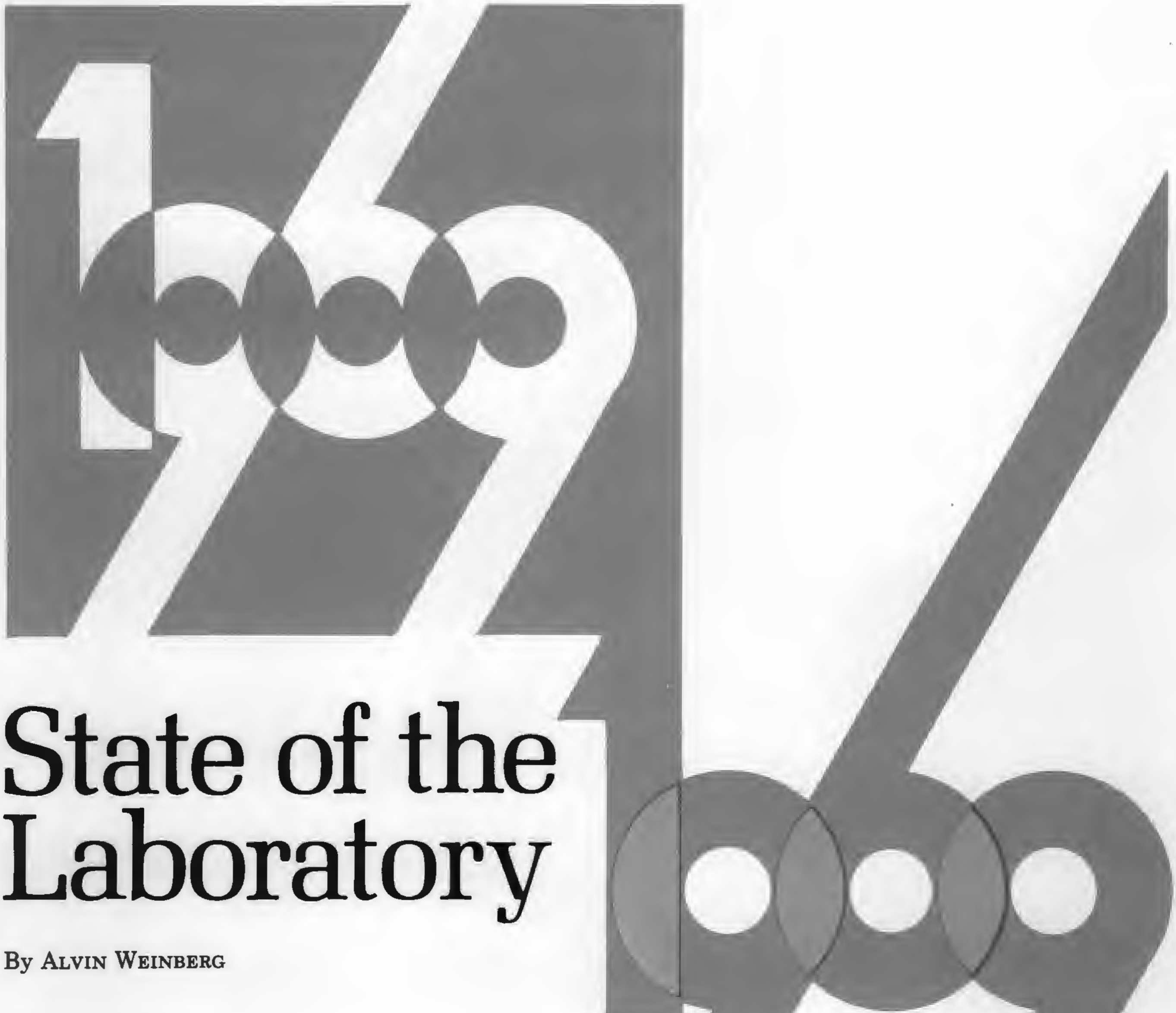


State of the Laboratory

By Alvin Weinberg

THIS HAS BEEN THE YEAR of the environment. On every hand we are being told that the fruits of technology are endangering our living space: nuclear energy in particular is blamed for causing some of this spoilation. This was the year of Sheldon Novick's *The Careless Atom,* and of Elizabeth Hogan and Richard Curtis's *Perils of the Peaceful Atom,* in which we are told, ". . . we should turn away from nuclear energy just as we have given up other unsuccessful technologies." This was the year of the public hearings in Vermont and Minnesota at which members of the Atomic Energy Commission, as well as S. I. Auerbach, W. L. Russell, J. B. Storer, D. J. Nelson, and W. B. Cottrell of ORNL, tried to reassure jittery public critics that the environment is being improved, not spoiled, by nuclear energy. It was the year of innumerable Congressional hearings, of reports and studies, of caucuses and study groups (including one at Oak Ridge High School), all concerned with the environment. "Environment" has become the O.K. word. The ecologists have displaced the physicists and the economists as high priests in this new era of environmental concern.

With all this going on, it was easy for me to choose as my theme for this 1969 report, ORNL and the

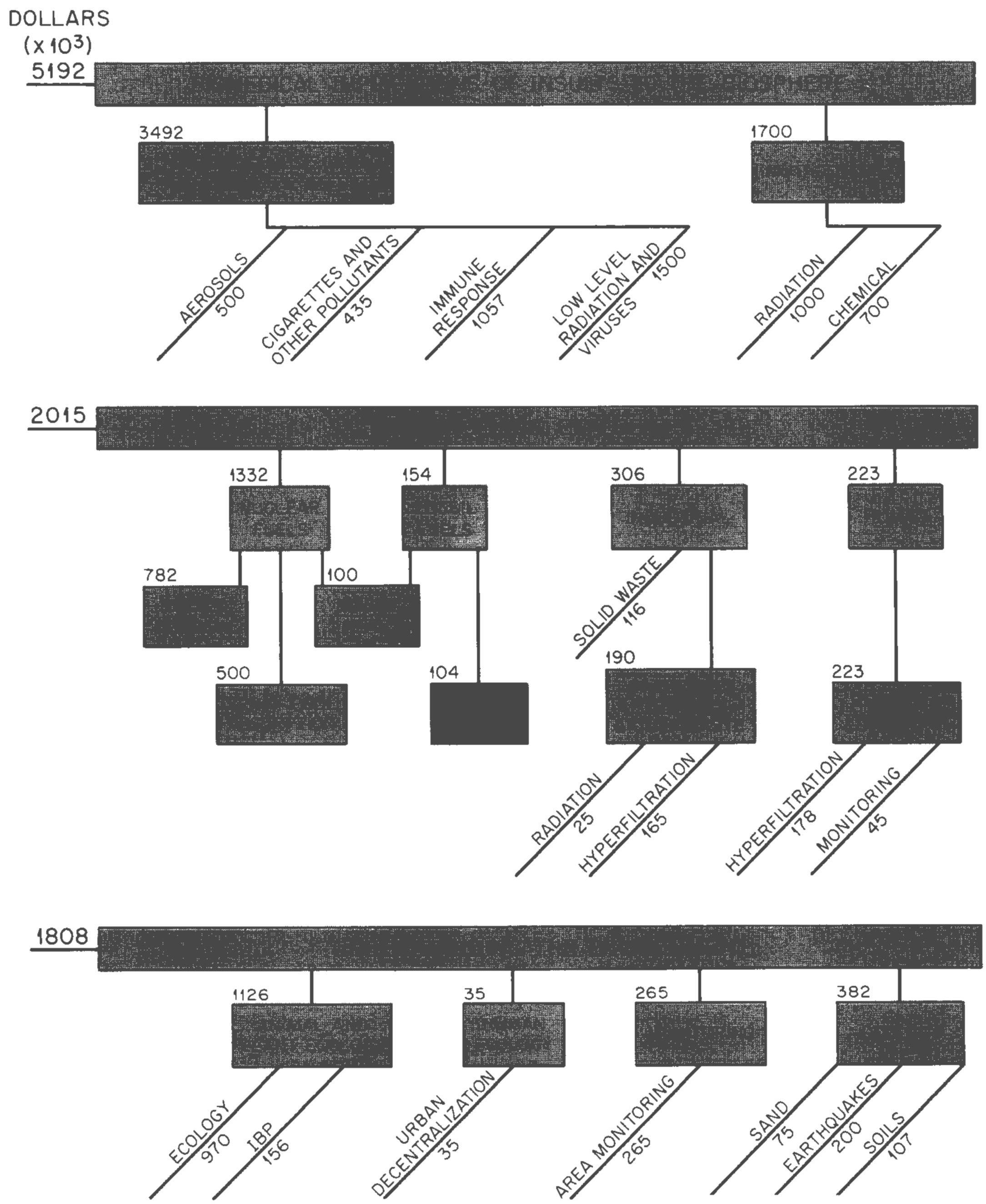


Figure 1. Environmental Studies at ORNL: $9,015,000.

Environment. The choice was all the easier since the other timely subject, ORNL and Money, is much less pleasant to discuss.

ORNL and the Environment

The nuclear energy laboratories have, for obvious reasons, been concerned with the environment since the beginning of the Manhattan Project. Handling large quantities of radioactivity without endangering the biosphere and particularly without endangering man was part of our task in 1943 when ORNL was started, and it remains an important part of our job. Our concern with the environment gradually broadened, and now some 10 percent of everything we do at ORNL is related to the environment. This broadened concern is sanctioned by the 1967 amendment to the Atomic Energy Act which

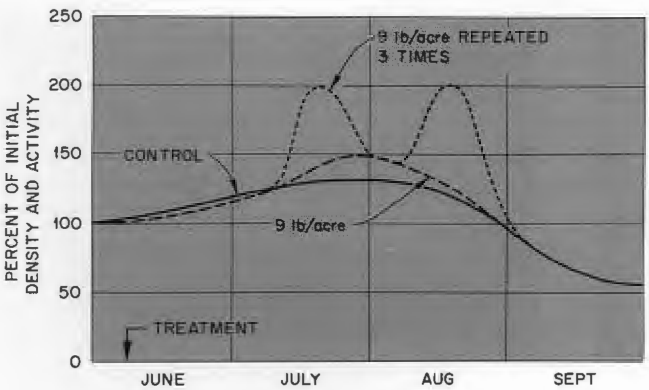


Figure 2. Effects of Single and Repeated Applications of Sodium Cacodylate on Soil Microorganisms.

directed the Commission "to conduct through its own facilities research and development or training activities for others, relating to the protection of the public health and safety."

The environment is uncomfortably diffuse and complex. Achieving a better environment is a less definite goal than is building a reactor: we know when we have finished a reactor, but we can hardly know when we have adequately cleaned up the environment. Many of our studies of the environment grew up a little at a time: they therefore present a confusing complexity that perhaps matches the intrinsic complexity of the environment.

We can group our work on the environment into three main categories (Figure 1): Understanding the Environment, on which we spent $1,808,000 last year; Controlling Effluents ($2,015,000); and Biomedical Implications of Insults to the Biosphere ($5,192,000). Of course not all that I list under "Environmental Studies" is equally relevant; nevertheless, it is fair to say that we spent last year about $9,015,000 and 300 scientific and technical man-years on these matters. We are *de facto* one of the country's largest environmental laboratories.

Understanding the Environment

In this category we have three activities: Geology, which includes a study of the capacity of soils to absorb radioactive nuclides; a study with radioactive tracers of the drifting sands off the coast of Santa Barbara; a study of bedded geologic deposits as disposal sites for radioactive wastes; and the science and technology of earthquakes. We began studying earthquakes because of their great importance to the siting of reactors. Three scientists and engineers under G. D. Whitman are familiarizing themselves with the phenomenology of earthquakes, and are trying to figure out ways of designing reactors to withstand serious earth shocks.

A second, rather surprising category, I designate Human Ecology. I refer here to a small study of urban decentralization undertaken largely as an outgrowth of our work in civil defense. The question was posed: What demographic and other factors would be involved if our country tried to decentralize? This obviously has implications for civil defense; it also has implications for the general quality of urban life. To carry out the study we brought to Oak Ridge last summer a distinguished demographer, Everett S. Lee, who worked with several social scientists from the University of Tennessee and engineers from Oak Ridge. Though the report of the study is not yet finished, we are impressed with the obvious possibilities it demonstrates for collaboration between the Laboratory and the University in research in socio-technical areas.

Finally, we have our very large group of Animal and Plant Ecologists. During the past year they have been concerned with such diverse projects as the effect of fertilizer runoff on the Walker Branch Watershed in the Oak Ridge area; retention of radioactive fallout on various agricultural crops; and management of the Eastern Deciduous Biome Research Program for the International Biological Program, to mention only three.

Of timely interest is a study of how organic arsenical compounds affect a grassland ecosystem. Because these arsenic-based defoliants are used in Vietnam, it is important to know just what the ecological consequences of widespread use of these compounds might be. The work at Oak Ridge carried out by C. R. Malone is one of the few projects aimed at finding answers to this important question and replacing emotional speculation with scientific fact.

Malone studied the effect of the herbicide cacodylic acid on the soil microorganisms that are so important in maintaining the ecosystem. He found that single applications of this herbicide cause an initial slight depression in the number and activity of the microorganisms, but this depression is followed quickly by a resurgence (Figure 2). Repeated applications of the herbicide do not appear to cause repeated suppressions but to the contrary result in stimulation of bacteria and fungi.

This surprising resurgence is explained by laboratory experiments which show that the herbicide causes the metabolic makeup of the microorganisms to shift. They gradually acquire the ability to metabolize these herbicides! Moreover, Malone finds (by neutron activation) that herbicidal arsenic remains in the soil only about three weeks. Apparently the microorganisms metabolize the parent chemical, producing gaseous arsenical compounds (like AsH_3) which escape to the atmosphere.

I do not imply that these few experiments have settled the messy question of the use of herbicides in Vietnam. I want mostly to show, by this example, how our ecologists are able to respond quickly to timely issues.

Controlling Effluents

Turning to the second category, Controlling Effluents, we find ourselves controlling nuclear, fossil, industrial, and human effluents. I have spoken many times of the contribution ORNL has made and is making to the disposal of radioactive wastes. We have no reason to doubt that the permanent disposal system advocated by ORNL—solidification and storage in salt—is perfectly safe. And, with such a ground swell of articulate though often misinformed concern over the safety of current radioactive waste disposal practices, our waste disposal people properly point out that we should begin to dispose of wastes in salt without delay.

I shall not say much about fossil fuel effluents: we are doing a little work for TVA on SO_2 removal, and we are also examining various alternatives for dissipating waste heat, from either a fossil or nuclear plant. One idea, proposed by S. E. Beall, would be to use the waste heat to heat greenhouses near a city in which vegetables for that city could be grown.

Our work on power plant effluents is being coordinated in a new Environmental Quality Study Project under the direction of J. H. Gibbons, including members of several divisions and the Nuclear Safety Information Center. The task of this group is to collect and assess our knowledge relevant to power plant emissions and siting criteria, to help fill in the gaps of incomplete knowledge, to aid in developing more effective ways to communicate with the public at large, and to directly assist the Atomic Energy Commission in carrying out its responsibilities in this area.

We are doing a little, again for HUD, on the disposal of solid waste in urban areas. An average of 4.7 pounds of solid waste is produced per person per day in the United States. Over 4.5 billion dollars is spent each year for the collection and disposal of solid wastes, of which 80 percent is for collection. With our experience in disposing of solid radioactive wastes here at ORNL it seemed natural for us to contribute to relief of this expensive headache. Mainly, W. J. Boegly, W. L. Griffith, and W. E. Clark (with the help of the MIT School of Chemical Engineering Practice) have been trying to reduce, by wet oxidation, the waste volume. This process was first used at ORNL for treating graphite fuel elements to recover uranium and thorium and later was studied as a treatment for sewage. Since paper and paper products constitute at least 50 percent of municipal solid waste, major emphasis has been directed to the wet oxidation of paper waste mixed with sewage. The small effort we have underway won't solve the solid waste disposal problem, but it does illustrate how we can contribute to new environmental technologies by exploiting our experience with re-cycling of nuclear fuels.

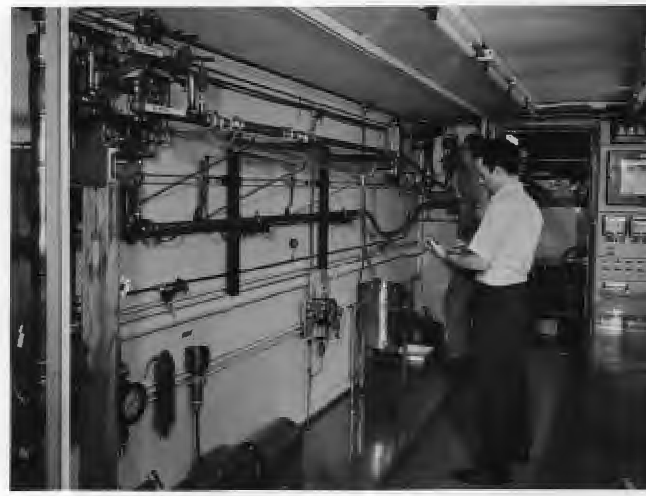


Figure 3. Hyperfiltration at the East Waste Treatment Plant.

I would like to dwell a little longer on our work on sewage treatment. Not many of you know that ORNL now has a sewage treatment pilot plant operating at the East Waste Treatment Plant of the City of Oak Ridge (Figure 3). One might well ask how in the world we got from nuclear energy to treating sewage. The route is not all that indirect: it is an outgrowth of the work on hyperfiltration of sea water sponsored by the Office of Saline Water, which itself derives from Kurt Kraus's knowledge and experience in solution chemistry, and the further work in hyperfiltration by J. S. Johnson, H. C. Savage, N. E. Bolton, and H. O. Phillips.

Typically, sewage is rendered innocuous to man by bacterial digestion—the so-called "activated sludge" technique. Kraus and his group instead are trying to replace the activated sludge treatment with a combination of cross-flow filtration and hyperfiltration. The contaminated supernatant from the settling ponds is pumped under very high pressure past a so-called "dynamic membrane." Pure water comes through the membrane, and the concentrated sludge and dissolved salts are removed as waste. If one adds a few ppm of certain polyelectrolytes, these membranes can be formed on fairly porous substrates—even on fire hose, though porous metal tubes are used in the Oak Ridge experiments. In last year's work at the sewage plant (carried out by J. A. Dahlheimer and J. S. Johnson), fluxes in excess of 50 gallons per square foot per day were achieved; oxygen demand was reduced by 85 percent and salt rejection was 60 percent. Remarkably, the bacterial count is down to drinking water tolerance after a single pass through the dynamic membranes.

Biomedical Implications of Environmental Insults

Our work on the biomedical implications of environmental insults constitutes the largest part of our contribution to the environment. If we really succeed in cleaning up the environment, in principle we shall not need to concern ourselves with biomedical implications. But to be realistic we shall never get that good and we must be able to deal with pathologies caused by residual noxious effluents. We are involved in both carcinogenesis and mutagenesis, induced by radiation and by chemicals, both singly and conjointly.

Chemical mutagenesis is far more complicated than is radiation mutagenesis, simply because there are so many more chemicals than there are radiations. Although W. L. Russell and his associates have already done experiments on genetic effects of chemicals in mammals, what is needed is a relatively simple assay system on which one can quickly measure the induction of gene mutations. Much of the new environmental mutagenesis program, which is coordinated by F. J. de Serres, is devoted to developing such assay systems.

The idea, first developed by investigators in the Food and Drug Administration, is to measure chromosome damage in individual cells, but to expose the cells to the insult not *in vitro*, but rather in a living mammalian host like a mouse. The mouse breaks down the primary chemical to which it is exposed, and it is these metabolic products, rather than the initial chemical, whose mutagenicity would be tested.

So far at Oak Ridge this "host-mediated" assay system, involving bread mold cells injected into mice (moldy-mouse experiment) has been used to evaluate mutagenicity of irradiated foods. Other techniques are being developed by E. H. Y. Chu for mammalian tissue cells, and by Grant Brewen for leukocytes. When these testing methods are perfected, it should be possible to measure accurately on human cells in culture the genetic damage in terms of gene mutation and chromosome breakage.

As you can see from this account of our environmental activities, the environment is complicated and diffuse. We are therefore taking steps to put more order into our effort. J. L. Liverman has been asked to include the environment among his general responsibilities; and I believe that J. H. Gibbons's Environmental Quality Study Project will help focus our efforts more sharply.

On a grander scale, an ORNL committee is preparing a prospectus for a National Environmental Laboratory. Let me tell you how this happened. Last summer we met with Senators Howard H. Baker of Tennessee and Edmund S. Muskie of Maine to exchange views about science and the environment. In the course of our discussions, it became apparent that to launch a fully coherent attack on something as complex as the environment, with its interrelated scientific, technological, and social components, would require powerful, coherent institutions—in short, National Environmental Laboratories. There have been many attempts to visualize such institutions. Perhaps most ambitious was the Argonne Conference on Universities, National Laboratories, and Man's Environment held in Chicago last July to formulate possible plans for moving massively into the environment.

With the informal blessing of the Commission, we at Oak Ridge have been trying to figure out just what a National Environmental Laboratory would look like. Not surprisingly, I guess, it seems to look like an expanded version of ORNL—expanded to include many more soft scientists. Two points have emerged in our committee's deliberations. First, since many environmental problems are the consequence of unforeseen side effects of technology, one is inevitably led to what is now known in Washington as Technology Assessment. Can one assess technologies *a priori* in any useful way? An

NEL would surely have to concern itself with such assessment.

Secondly, management of information emerges as a central element of an NEL. This seems to bear out a prejudice that is peculiarly Oak Ridge (with its 12 information centers). In very complex situations which possess technological components but which cannot be unified by an underlying theoretical structure, the information center might provide this unification. We have seen this happen in the Nuclear Safety Information Center where one is also dealing with a very complicated situation, or even in civil defense where our small group seems to serve as a focus for mobilizing pertinent information. This is happening in the environment with the formation of the Biogeochemical Ecology Research Collection, the Environmental Quality Study Project, and a new chemical mutagen information center (under Heinrich Malling). The information center as a unifier of research is an intriguing idea, vague though I confess it still to be—but it may prove to be important.

The committee's prospectus is not for an Oak Ridge National Environmental Laboratory, and this is deliberate. The question is open as to where such a laboratory ought to be located or whether it is to be a new laboratory or a redeployed old one. Nevertheless, we can say two things: first, that the environment is obviously acquiring very high priority. I remind you that President Nixon is chairman of the Environmental Quality Council, of which Lee DuBridge is Executive Secretary. That this will lead to much activity, some of it scientific and technical, in the environment, I have no doubt. And second, as the conference at Argonne, as well as our own committee's deliberations bring out, the AEC National Laboratories are as close as anything that exists to being NELs. It does not take too great a flight of imagination to anticipate our becoming more involved in the environment, whether or not we ever eventually become an NEL.

Energy—A Key to the Environment

But what about our commitment to energy? We after all are primarily an energy laboratory, not an environmental laboratory. Yet there is a close connection between energy and environment: on examination of the man-made effluents that pollute the environment, one finds that the most important ones are connected with energy transformations. One can add to the obvious list of combustion products, both from automobiles and from large-scale generating plants, acid drainage from coal mines, unsightly stripping, and heat, also the industrial effluents, largely smoke and CO_2, that result from using carbon as a reducing agent in heavy steel production.

I know of no systematic examination of the implications for the environment of a thorough-going conversion to nuclear energy; my impression is that the environmental implications would be substantial, and that in this sense the nuclear energy laboratories are attacking pollution in a very fundamental, if long-range way.

During the past year, our work on reactors has continued along the lines that we have been pursuing for several years. What we do at ORNL is largely a reflection of what concerns the Atomic Energy Commission. Thus the highest priority reactor project within the Commission is the Liquid Metal Fast Breeder Reactor (LMFBR). It accounts altogether for some $175,000,000 of the approximately $525,000,000 the Commission spends on all reactor research. And, surprising as it may seem to those who are not close to the situation, the LMFBR provides the motivation as well as the funds ($9,500,000) for better than 30 percent of all the reactor work we do at ORNL.

The central problem of the breeder remains, as it has for 25 years, the rationalization of the fuel cycle. In the fast breeder this means developing fuel elements that can withstand very long radiations, until, it is hoped, 10 percent of the heavy atoms are used; and it means simplifying and cheapening the chemical processing. Of course what has to be accomplished in the chemical process depends on how much radiation the fuel can withstand, and therefore how often the fuel must be recycled before being reprocessed.

What limits fuel burnup in the fast breeder? First, the oxide fuel expands during irradiation. The expansion is caused by fission products that are trapped in the oxide and cause the matrix to swell. Secondly, voids and helium bubbles form in the stainless steel cladding under irradiation, cause it to expand, and embrittle it. This radiation embrittlement was first noticed at ORNL during ANP days; it now looms as one of the most difficult problems in the LMFBR.

We at ORNL are contributing significantly to resolving both these questions. For example, we have used the sol-gel process to manufacture $(U,Pu)O_2$ microspheres that show promise of retaining adequate integrity out to 10 percent atom burnup. And, with respect to the deterioration of cladding materials under intense bombardment, our initial findings that 0.2 percent titanium improves the resistance of the cladding continue to hold up as we go to higher fluences. So far there are no data in the range that we require for an economical LMFBR (2–3 $\times 10^{23}$ neutrons/cm^2); the whole reactor community anxiously awaits results in this range.

Our laboratory has the responsibility for developing the chemical reprocessing of LMFBRs. The general plan is to modify existing aqueous chemical processing plants, rather than build new ones, especially for LMFBRs. Since the same basic solvent extraction process will be used to process LMFBR oxide fuels as is now used to reprocess light water oxide fuels, most of our effort is directed toward modification of the head end of the plant where the fuels are dejacketed and dissolved.

The alternative approaches to the breeder—the seed blanket, the Gas Cooled Fast Reactor, and the Molten Salt Breeder Reactor—receive much less support from the Commission. The alternative most heavily supported is the seed blanket breeder: a pressurized water reactor fueled with thorium and U^{233}. The reactor has the virtue of exploiting pressurized water technology. It has the disadvantage of not breeding if it is operated most economically. The Shippingport reactor is being converted to a seed blanket prototype; we are responsible for producing the Th-U^{233} oxide for the reactor.

A second alternative to the LMFBR is the Gas Cooled Fast Breeder Reactor. This breeder uses technology already developed for gas cooled reactors both here and abroad. Gulf General Atomic is pushing this idea; we are giving some support as part of our gas cooled reactor program, the main part of which is concerned with the graphite moderated HTGR. One of the most interesting developments is the prestressed concrete pressure vessel which would be used in a gas cooled fast reactor or in an advanced high temperature graphite reactor. In Figure 4, I show a small mockup of a prestressed concrete vessel. As G. D. Whitman and J. M. Corum's experiments show, such vessels cannot fail catastrophically. It is not unlikely that prestressed concrete reactor vessels will find a place not only in gas cooled reactors but possibly even in boiling or pressurized water reactors.

Finally I come to the MSBR. This reactor, which John Maddox, editor of *Nature*, refers to as Oak Ridge's "Pride of Place," commanded about $6,000,000 of Commission funds—some four percent of what is being spent on the LMFBR. This has been a year of happy technical advances. The MSRE continued to operate very well with U^{233} as fuel. In September we began to refuel with PuF_3, and the reactor then produced about five percent of its energy from fission of plutonium. Our chemists now find that PuF_3 is sufficiently soluble, and is sufficiently insensitive to oxide precipitation, to allow its use as a starting fuel for molten salt breeders. Thus we are confident that molten salt reactors, no less than fast breeders, can use the excess plutonium produced in light water reactors.

MSRE was shut down December 12 because we ran out of money. After shutdown a small leak developed in a drain line, which raised the gaseous activity in the containment cell. The reactor's operating history with U^{233} during 1969 is shown in Figure 5.

As far as I am aware no other reactor experiment has matched MSRE either as to percent of time on

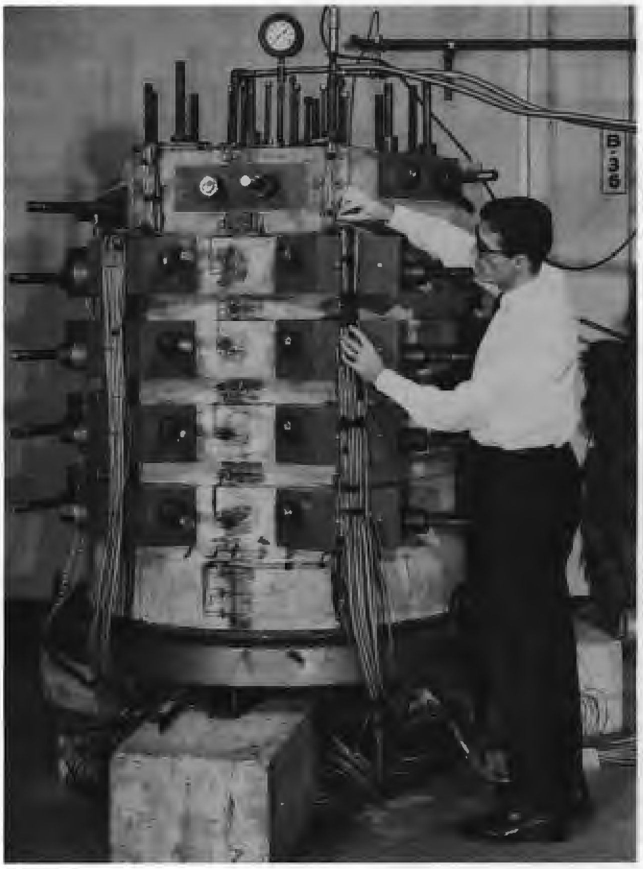


Figure 4. Prestressed Concrete Pressure Vessel.

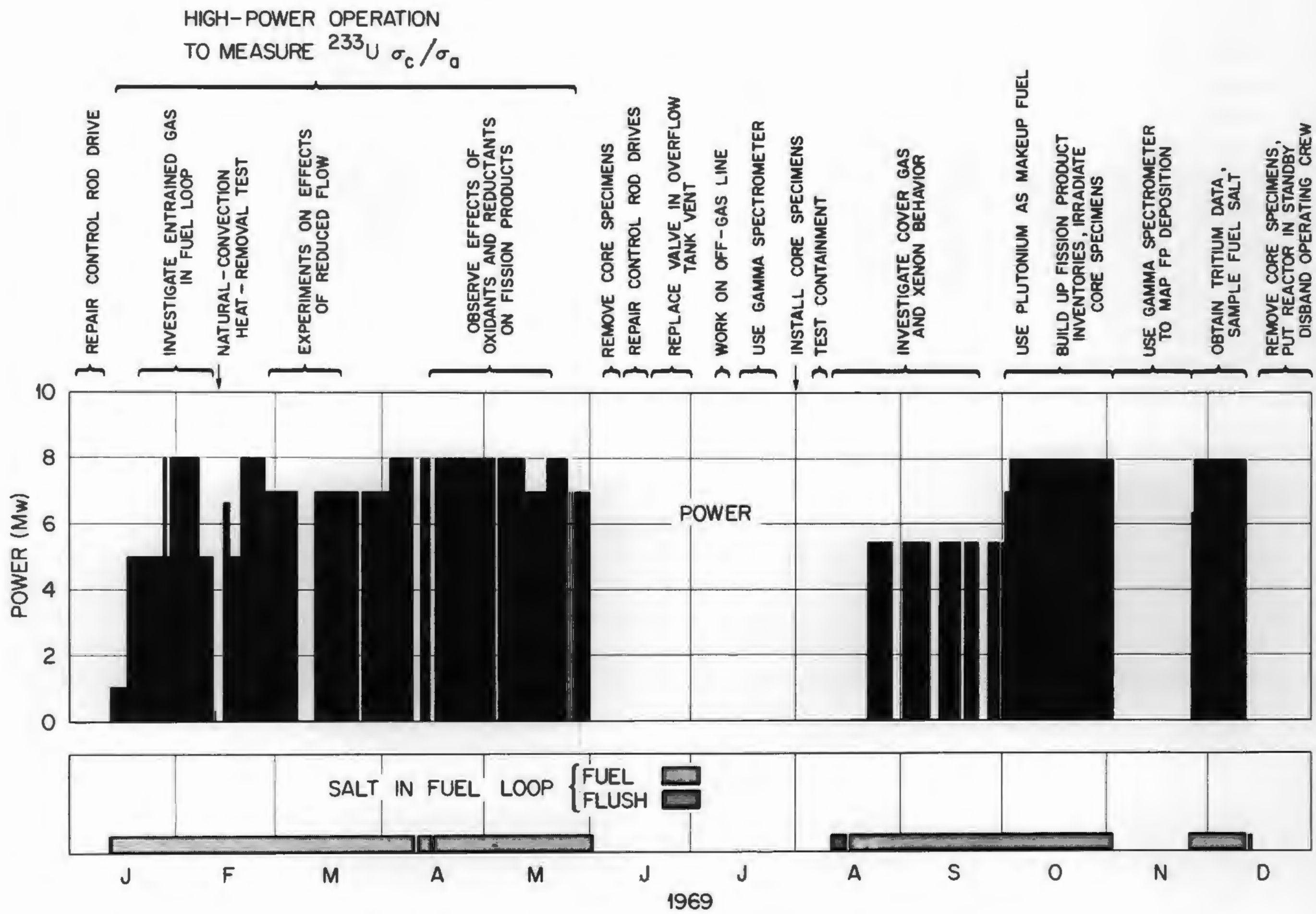


Figure 5. Outline of ^{233}U Power Operation.

the line since it began regular power operation December 14, 1966, or as to length of its most sustained run (188 days). We plan to put MSRE in standby; the fuel is now in the drain tanks, but we do not plan to repair the drain line unless we run the reactor again. The MSRE has been a major technical success, of which all who have participated can be immensely proud.

Probably the most significant advance, and this has been a lulu, has been in the processing of the rare earths. For MSBR to breed, its fuel must be purified regularly. This we plan to do by passing the fluid through a "kidney," a reductive-extraction unit that takes out first the protactinium and then the rare earths. The protactinium step always looked good: separations from uranium and from thorium were sharp, but the rare earth separation was marginal. We were all tremendously pleased when L. M. Ferris and L. E. McNeese, with assistance from A. S. Meyer, came up with a salt transfer scheme that on laboratory scale shows separation factors between rare earths and uranium of more than 6000. Thus all of the basic chemistry steps for a successful kidney now seem to be well in hand.

We are ready to go to the next step—the MSBE. But not much can be done without money. We have requested $15,000,000 for the coming year; this would be enough to put us into the high gear for which the technology is now waiting. This is not a propitious time to solicit more money; yet, being an optimist, I hope our request will receive most careful attention from the Commission.

Controlled Fusion

The big news in fusion this year was the TOKAMAK. TOKAMAK is a Russian plasma device in which an intense ring current creates a hot plasma and is confined in a magnetic torus. The ring current is sufficient to produce its own magnetic field in addition to the original confining field.

In the United States, fusion physicists have been watching the succession of TOKAMAK machines in Russia, believing that the mixture of the three functions of the ring current (creation of plasma, heating, and confinement) would give such a confused situation that understanding would be difficult. This is to some degree true; there is still no proper theoretical understanding of TOKAMAKs, but the Western World was forced to take notice over a year ago when Artsimovitch announced that the latest TOKAMAK results indicated a combination of plasma density, temperature, and lifetime markedly superior to those of any in the United States or the rest of the world. A British team left for Moscow to check one aspect of the measurements, later to announce full corroboration. Meanwhile, there was a quick decision that the U.S. should start this kind of work, and a scramble ensued as to who should get the mission.

At Oak Ridge there was a decision several years ago to initiate some kind of toroidal plasma experimentation, and this was started by Igor Alexeff and Michael Roberts. Their apparatus was basically somewhat like a TOKAMAK, using a doughnut with a linking transformer core. Their experience led to a particularly neat TOKAMAK design, called ORMAK, in collaboration with G. G. Kelley and J. F. Clarke. It won the U.S. competition for special funds, and is now under design and construction.

Figure 6 shows ORMAK as a wooden model, in mid-section. You see the plasma ring in the vacuum doughnut above, and in the center the black transformer core that drives the plasma current. The plasma ring will be about a meter in diameter, and the whole of the black transformer will weigh 15 tons. The longitudinal confining field is provided by a massive copper envelope about the vacuum torus. This envelope is actually a single-turn secondary of another transformer (a step-down transformer) the core of which is the 20-ton iron doughnut below, and in fact the copper wraps itself around both tori.

In operation, this whole assembly will be cooled to liquid nitrogen temperature to reduce the resistance in the copper. Four of our three-megawatt motor generator sets will be spinning, and the output of all four will be simultaneously slammed into primary windings which are not shown but which are wrapped about that lower toroidal transformer core. This will induce a current surge of ten million amperes up and around the vacuum torus, producing a magnetic field of 50 kilogauss within it. At the correct split second, a large battery will be unloaded

Figure 6. Cutaway Model of New Controlled Fusion Experiment.

into the primary of the black transformer, and this will produce the toroidal plasma. Measuring instruments will snatch out their information, and the experiment will be over in about a second. The nitrogen bath will bubble furiously for a few minutes, but then ORMAK will cool down again, and it will be ready for another wallop.

What will ORMAK do that the TOKAMAKs have not done? I mentioned that there is little theory behind the TOKAMAKs, but trends have been found by the Russians. High magnetic fields are beneficial, and so is a close, fat doughnut.

ORMAK I will actually be proportioned to reproduce the best of the current TOKAMAKs, with capability of a much higher magnetic field and a much longer pulse. But it is designed so that the upper torus can be split off, and be replaced by a fatter one. This will be ORMAK II, and here Kelley, Roberts, and Clarke will be in new territory. With great good luck, ORMAK II might tell us that it would be a good gamble to go to a big ORMAK III, which might be the fusion equivalent of the 1942 experiment at Stagg Field in Chicago.

Middle East Study Project

Let me now turn to our Middle East Study which is aimed at exploiting, rather than producing, nuclear energy. As you recall, we have had a team studying, under the guidance of J. A. Lane and C. C. Burwell, the nuclear-powered agro-industrial complex as an instrument for development of the Middle East. The ORNL group has looked at three com-

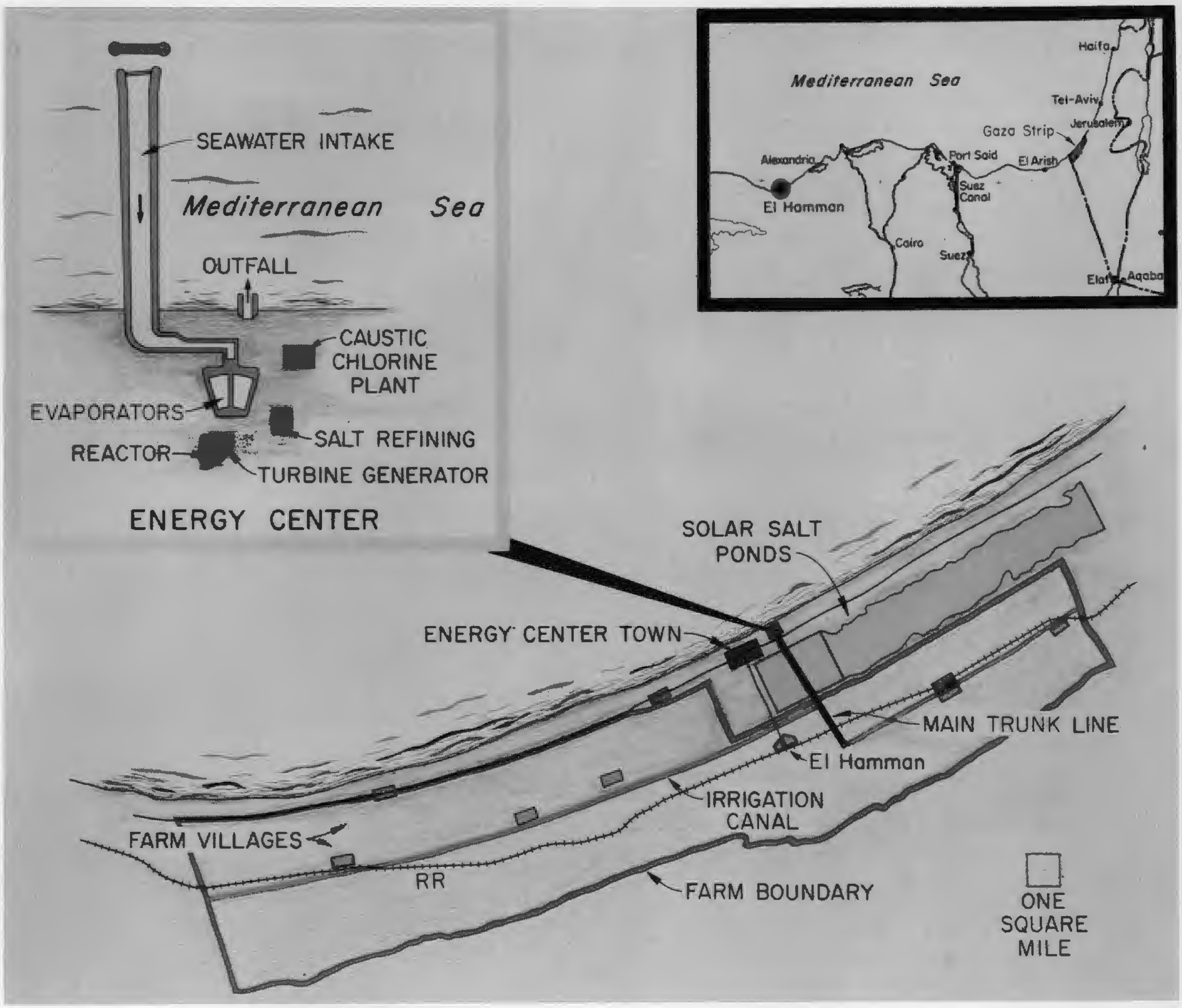


Figure 7. Concept of an Agro-Industrial Complex for Egypt.

plexes: national projects in the El-Hamman area of Egypt, and in the Western Negev area of Israel, and a project near the Gaza Strip. The layout of a possible complex in the El-Hamman area is shown in Figure 7.

In general, after having studied these possibilities for more than a year, the group finds that a national project in Egypt might return something less than 10 percent of the investment; that in Israel, where desalting is almost taken for granted, the idea makes better economic sense; but that the scheme shows most promise near the Gaza Strip. Our findings are now being forwarded to the appropriate authorities.

All of the schemes contemplate using desalted water for agriculture. It was something of a shock to read in the June 6 issue of *Science* an article by Marion Clawson, Hans H. Landsberg, and Lyle T. Alexander that for the next 20 years the cost of desalted water will be "at least one whole order of magnitude greater than the value of the water to agriculture." Since this view so sharply contradicts views expounded here at ORNL, Gale Young prepared a response, "Dry Lands and Desalted Water," which is to appear soon in *Science.* I shall not go into the details of Young's refutation except to point out that the whole case for using distilled water for agriculture depends not on using water sparingly (in fact, the crop is expected to luxuriate in moisture) but rather on increasing the yield so as to bring the specific yield—i.e., pounds of grain per 1000 gallons of water—up to an acceptable level. The exciting new finding this year has been that rice, which feeds most of the hungry people in underdeveloped lands, apparently can be grown in such a way as to require only 150 gallons of water per 2500 calories of rice. Thus rice now joins wheat and corn in requiring not more than five cents' worth of distilled water to grow enough grain to sustain an adult for a day. This new finding, based on recent experiments in India, could be a major breakthrough in the attempt to feed the growing millions of underdeveloped Asia.

Basic Research—Big Machines, and Isotopes

As for big machines of basic research, the major concrete achievement has been the successful operation of ORELA. The machine was taken over by the Laboratory on August 25, 1969, and it has been producing a very satisfactory beam (15 amperes at 140 MeV; 3–24 nanosecond pulse widths; up to 1000 per second repetition rate). In Figure 8 I show the neutron cross section of U^{238} measured at ORELA by Gerard de Saussure, E. G. Silver, and R. W. Ingle. Notice the extraordinary wealth of detail; it is no wonder that to process all this data ORELA requires a full-fledged computer.

Our last three pieces of big scientific machinery, HFIR, MSRE, and ORELA, have been notable successes. With the confidence derived from these successes, we have proposed to the Commission that the combination TU Van de Graaff and cyclotron I described last year be built in Oak Ridge. This system would accelerate heavy ions into the range where they can possibly create super-heavy elements. One gets the impression that these elements are being taken more and more seriously: for example, T. A. Carlson, with F. B. Malik (consultant), T. C. Tucker and C. W. Nestor (Mathematics), computed the energies of the various x-ray lines from element 114, using methods they had developed for dealing with lighter elements.

Technically not much has changed. We have named the accelerator *A*ccelerator for *P*hysics *A*nd

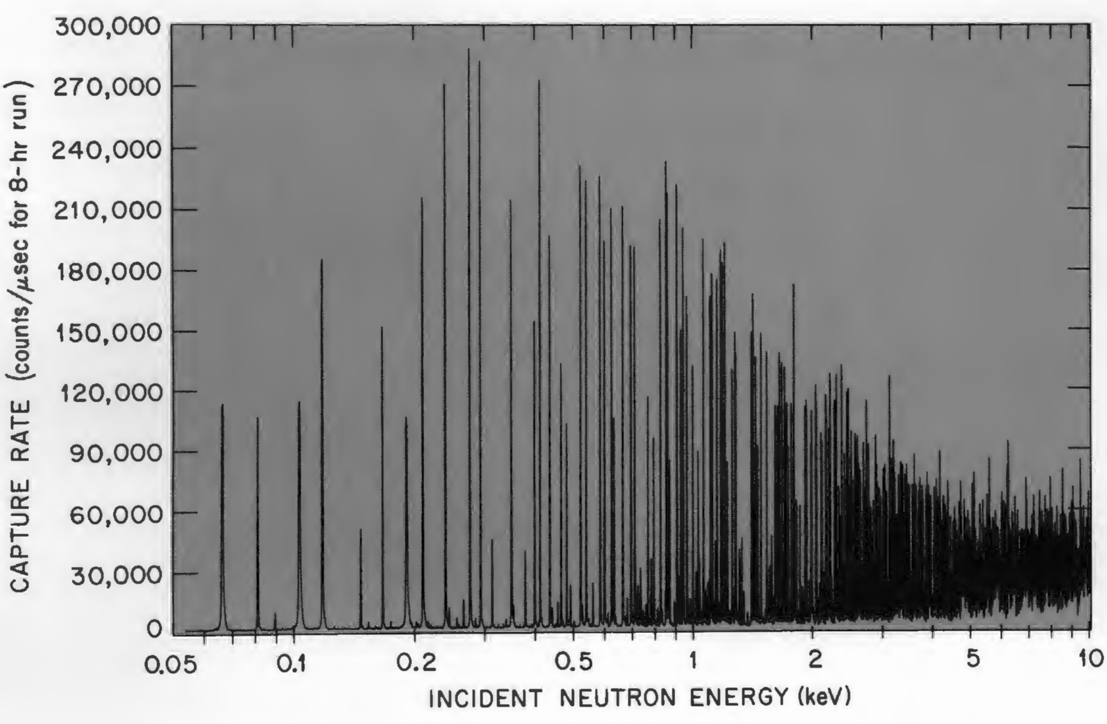


Figure 8.
^{238}U Capture Rate vs. Energy

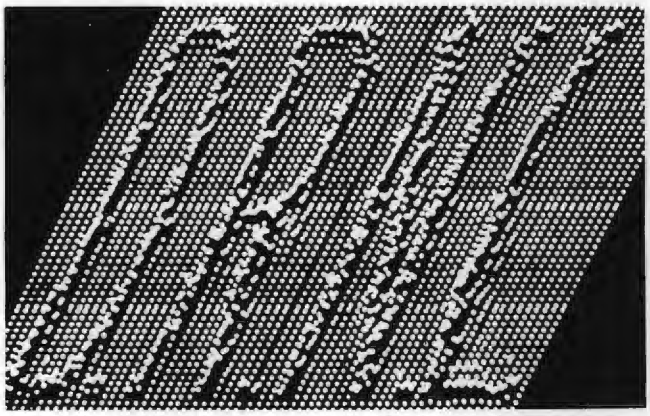


Figure 9. Initials Stenciled by Position-Sensitive Charged Particle Detector.

Chemistry of Heavy Elements (APACHE) (we couldn't work out words to match the acronym CHEROKEE); we have estimated its cost at $25,-000,000, this being the amount assigned to the project by AEC; we have mobilized impressive support from the southern universities; and we have submitted a formal, large-scale proposal to AEC. Two things becloud the future of APACHE. First, there are at least a dozen other proposals for accelerators aimed at these same scientific goals; and second, the Bureau of the Budget says No (for the time being). My own estimate is that at least one version of APACHE will be built eventually, and that ORNL has as good a case (and with our strength in heavy elements perhaps a better case) as has the competition.

As for isotopes, we continue to serve both the scientific community and the users of isotopic power sources. In the latter category, we distributed 16 megacuries of Cs^{137} and 1.25 megacuries of Sr^{90}. The separated stable isotope business increased 10 percent to 1.1 million dollars, even though we sent back to the U.S. Treasury Department the last 67 tons of the original 14,700 tons of silver used in the wartime calutrons. And we continue to do things that now we take for granted but which 20 years ago would have been considered fantastic—like producing 50 grams of U^{233} with less than 20 ppb U^{232} contaminant (for cross-section measurements), or kilogram quantities of 85 percent Fe^{57} for the single-crystal neutron polarizers needed for neutron polarization analysis by W. C. Koehler and R. M. Moon.

Miscellaneous Items in Basic Research

First, our involvement with the Apollo 11. The Laboratory contributed (in addition to P. R. Bell who has been head of the Lunar Receiving Laboratory) some of the auxiliary hardware—such as the equipment for transferring lunar samples while maintaining vacuum over the samples at the LRL.

Two groups from ORNL, one headed by G. D. O'Kelley, the other by R. A. Weeks, are examining the radioactivity and the magnetic properties of lunar rocks. O'Kelley was present at the Lunar Receiving Laboratory in Houston to determine the short-lived radioactivities in the newly arrived moon rocks. The counting apparatus at Houston was designed and built at ORNL. A most interesting preliminary finding is the great age of the igneous rock, indicating, according to O'Kelley, that the moon rocks crystallized earlier than the earliest rocks found on earth.

A most exciting instrument development has been made by C. J. Borkowski and M. K. Kopp. This is a one-dimensional, position-sensitive proportional detector that can measure simultaneously the location, energy loss, and time of occurrence of charged particles and low energy x rays. Such position-sensitive detectors could revolutionize one aspect of x-ray crystallography: because they record energy and intensity as well as position, they can make of Laue spot-photography a precision, quantitative technique. Moreover, because they record many positions simultaneously, they could be most useful in analysis of complex molecules. These detectors will undoubtedly be very useful in charged-particle scattering experiments, detectors in magnetic spectrometers, etc. To illustrate their versatility, Borkowski and Kopp used one of them to image a stencil through which alpha particles passed onto the counter (Figure 9).

I turn now to a beautiful new technique in ceramics that has come from G. W. Clark and J. C. Wilson of the Metals and Ceramics Division working in collaboration with A. T. Chapman and R. J. Gerdes of Georgia Tech and D. E. Hendrix of ORGDP. Clark and his co-workers have succeeded in preparing ceramic-metal eutectic mixtures in which the metallic phase is dispersed uniformly as tiny, parallel rods. Such oriented eutectics had been created in metal-metal systems, but very little had been done with ceramics. In this work UO_2 and tungsten powder are mixed in a device for growing crystals of high temperature materials under a centrifugal force gradient. The resulting eutectics consist of surprisingly regular arrays of tungsten rods imbedded in a UO_2 matrix (back cover). It is little wonder that this and one other of Clark's pictures won Best of Show for the 1969 Ceramographic Exhibit of the American Ceramics Society. Though it is early to say exactly what will come of these new materials, it is not hard to visualize their use wherever one wishes to strengthen a ceramic or increase its electrical and thermal conductivity (perhaps in fuel pellets?).

Looking to the Future

This has been a tough year, perhaps the toughest since ORNL was organized. Because of the budget squeeze, we have had to reduce staff very significantly. Such an operation is always painful; in a small self-contained community like Oak Ridge, when a person loses his job he usually has to leave, and this adds to the hardship. We have tried to do the best we could under the circumstances, but I am afraid many unhappy readjustments will have to be made.

I shall try to explain just why the budget has been such a headache this year. Last year the Laboratory spent \$92,500,000 in operating money. This year our current financial plan shows a total of \$93,900,000. As you know from reading *The Oak Ridger,* the Molten Salt Reactor received an appropriation of \$8,000,000 instead of \$5,000,000; but only the original \$5,000,000 was allocated.

Even though our total dollars for FY '70 are a little higher than in FY '69 (largely because of added support from other agencies), we have had to reduce the size of the Laboratory: it costs six percent more per year to do business because of inflation; in addition, the refinancing of the pension plan to conform to more acceptable actuarial standards has increased our overhead several percent. The upshot of the matter is that we have had to take drastic action to stay within our budget. Inevitably the output of the Laboratory will suffer—as I'm afraid will its morale. This is the price that we must pay in these days of tough sledding for science.

It is some consolation to realize that times are hard all over. Our country seems to have slipped

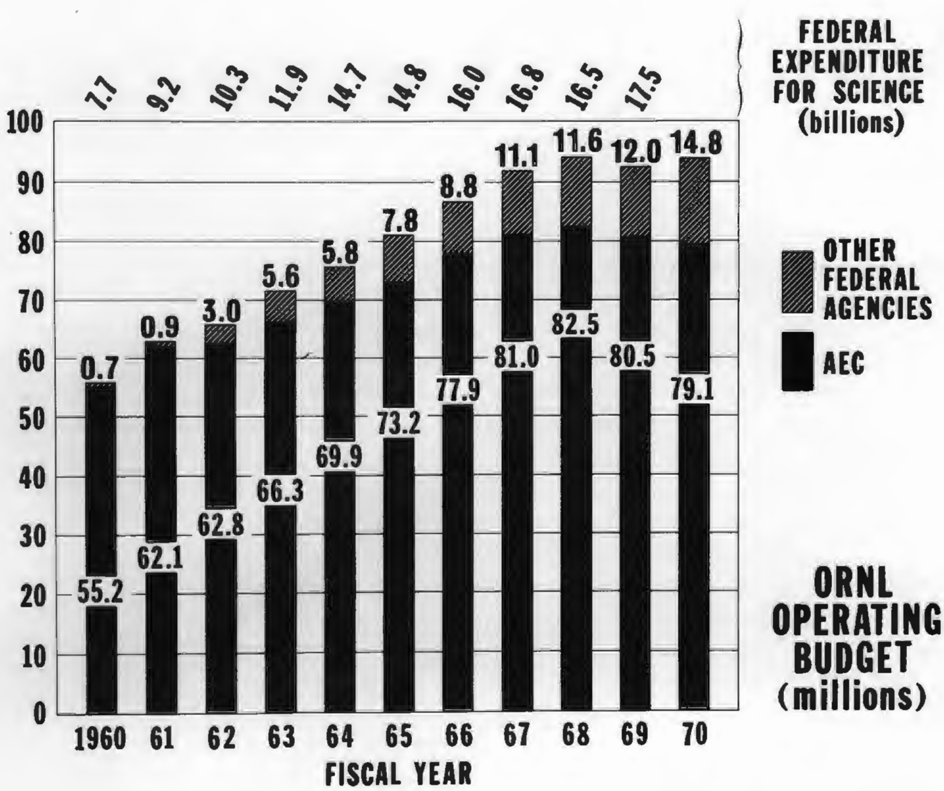


Figure 10. The ORNL Financial Picture over a Decade.

into an anti-scientism—a sort of New Luddism—that is reflected in less money for science. But this is only part of the story. Support for science increased regularly and substantially for 15 years beginning in 1950. In 1965 it began to level off, and in the past four years it has remained almost constant; thus science as a whole has suffered a reduction of 25 percent in real dollars over these years. The budget of ORNL during this time mirrors the budget for science as a whole (Figure 10). This leveling was probably inevitable. We have up until now not generally had to live with a constant budget, though some parts of the Laboratory have already had such experience. This new state of affairs requires us to make sharper choices, and to eliminate what we once thought were necessities.

I cannot really say what the future will bring. As far as AEC is concerned, we must remember that the AEC's total budget is falling, not rising. It therefore seems to me unlikely that our budget will increase during the next couple of fiscal years until the MSBE is authorized. On the other hand, our involvement with other matters of national concern, particularly the environment, could well provide new, substantial sources of additional support. The question is, when?

It is necessary for us to keep things in perspective. Though our budget has been cut, we still operate with $93,900,000 this year. Though the MSRE did not get its $8,000,000, industrial interest in it is growing. Though APACHE was tossed out of this year's budget, it is still very much alive, and there will be other years. Though the country's budget for fusion hardly increased, we are going ahead full steam on ORMAK.

A laboratory, like a person, goes through happy times and sad times. The strength we gain from our successes, from our happiness, sees us through our sadness and our failures. Our institution has been remarkably successful and resilient: it has had tough times before (as when ANP was canceled in 1957) and has bounced back. All of us must have confidence, and perhaps a touch of faith, that from these temporary setbacks will come a stronger, more aggressive, and more successful Oak Ridge National Laboratory.

NADER ON SCIENTISTS

. . . And I'd like to end with a suggestion—a very modest one because only modest suggestions have any possibility of being realized in the immediate future—and that is that the Laboratory initiate a tradition of public hearings which it attaches to the Lab (let's say once every month or once every two months) where major issues—major social and health and safety issues—pertaining to the research going on at the Lab, be discussed; and that those who are working in these areas begin to testify concerning their parascientific concerns, as an outgrowth of their scientific expertise; and that these hearings be open to the public; and that they be transcribed; and that they be published; and that they be structured in such a form where a scientist or a technologist or any specialist at the Lab can stand up here and be a full-dimensional person and talk about his whole range of concerns—not just as a scientist or an expert, but as a citizen, as a consumer, as a father, as many roles as he plays throughout society. And so, for the first time perhaps, we will have the kind of focused and relevant dialogue by people in these areas of expertise that will sound the alarm throughout the nation—that this notion, this long-held notion, that a person must "stick to his last" is probably one of the most devastating and dysfunctional attributes of brilliant human minds. And, if all of *you* stick to *your* lasts, you may soon witness the last generation.

—Ralph Nader at ORNL, August 18, 1969.

Paul Blakely moved to Oak Ridge in 1943 right after receiving his undergraduate degree in chemistry from Washington & Lee University. Since then he has acquired a master's degree in business administration from the University of Tennessee. He moved from Tennessee Eastman to ORNL in 1947, where today he is a member of the Nuclear Safety Information Center and managing editor of the *Nuclear Safety Journal*. Last September he was appointed chairman of the Special Committee of the Nuclear Standards Board. This article is taken from a talk delivered to the Southeastern Regional Meeting of the American Chemical Society last November in Richmond, Va.

Nuclear Standards–Everybody's Business

By J. Paul Blakely

"THERE'S NEVER TIME TO DO IT RIGHT–but there's always time to do it over."

We've all experienced this situation: we see it every day in the recall of new cars for *proper* installation of widgets, the withdrawal of cyclamates from the open market, the increasing delays and attendant cost escalation of licensing and construction of nuclear power plants. Since time is money, these "discretional errors" cost us: in taxi-fare or inconvenience when the car's in the shop, in increased drug and food costs when cyclamate manufacturers try to recoup their investment in a suddenly disallowed product, in higher energy costs when a planned power plant fails to go on-line on schedule or has been up-costed by a factor of two or three.

Standards Would Help

Problems of this general nature would be alleviated, if not obviated, by the application of appropriate and effective standards–standards on the proper installation of widgets, on the ways of studying long-term effects of food additives, on parts and procedures to be used in nuclear power plants. I believe that it's obvious that without standard screw sizes and thread pitches, or standard chromatographic techniques, or standard pump discharge rates, our technological society would never have developed. It's equally obvious then, for our increasingly important nuclear technology to make its rightful contribution, that we need more nuclear standards. We need them fast, and we all need to be aware of and adherent to those that already exist.

American standards are traditionally voluntary standards, and are traditionally developed over a period of many years as a particular technology evolves. The luxury of time is no longer with us, however, and technology is advancing so much more rapidly than its parametric standards that the Federal Government is preparing to step in and promulgate its own standards if industry fails to take up the slack—in all areas of technology, not just nuclear. Lou Roddis, president of ANS and of Con. Ed., in a talk last fall in New York, gave as one of the three most important needs for nuclear standards the establishment of engineering practices that are understood by industry *and used by industry*. This, in his opinion, is the best example of why standards should *not* be developed by Government. *Industry* knows what is needed. Mr. Roddis's

A facsimile page from USA Standard N10.1, approved 1968, on Nuclear Reactor Classification. Sponsor: ANS; prepared by subcommittee ANS-9.

1. Scope and Purpose

This standard classifies nuclear reactors into three primary categories, lists the major classes within each category, and lists the identifying reactor names associated with each class. (See Table I.) The purpose of this standard is to standardize reactor nomenclature. Use of this terminology is recommended.

2. Definitions

The terms used here are defined in USASI N1.1-1967, A Glossary of Terms in Nuclear Science and Technology, or were developed for use in this standard (see Appendix).

3. Classification by Purpose

Nuclear reactors are divided into the following classes based on purpose: developmental, power, research, training, irradiation, and fissile-material production.

3.1 A developmental reactor is a reactor that provides reactor physics, engineering, and/or operating data for the several stages in the design and development of a reactor or reactor type. Reactors in this class include:

- experimental reactor
- demonstration reactor
- prototype reactor

3.2 A power reactor is a reactor whose primary purpose is to produce power. Reactors in this class include:

- electric-power production reactor
- propulsion reactor
- process-heat reactor

3.3 A research reactor is a reactor used primarily as a tool for basic or applied research. Reactors in this class include:

- low-flux research reactor
- high-flux research reactor
- pulsed reactor
- materials-testing reactor (may also be an irradiation reactor)

3.4 A training reactor is a reactor primarily for training personnel in reactor operation and instructing in reactor behavior.

3.5 An irradiation reactor is a reactor primarily for irradiation of materials or for medical purposes. Reactors in this class include:

- food-irradiation reactor
- chemonuclear reactor
- biomedical-irradiation reactor
- material-processing reactor
- isotope-production reactor
- materials-testing reactor (may also be a research reactor)

3.6 A fissile-material production reactor is a reactor primarily for the production of fissile material.

other two main reasons for nuclear standards are 1) to ensure that only materials and equipment whose quality is consistent are obtained and used in the nuclear power industry, and 2) to establish that the important features of equipment are properly evaluated during design, procurement, fabrication, installation, operation, and maintenance.

How It's Done

The American National Standards Institute (ANSI) is the clearinghouse and coordinator for all general standards activities in this country. It started in 1918 as the American Engineering Standards Committee, was reorganized as the American Standards Association ten years later, reorganized again in 1966 to allow government participation and renamed the United States of America Standards Institute, and *re*renamed, just last fall, the American National Standards Institute in part to avoid the occasional misinterpretation that it was an arm of the federal government.

ANSI does *not* write standards; it *does*, however, provide a systematic means of developing standards, promote their use, and approve as ANSI standards those standards that are accepted by a consensus of all national groups substantially concerned with their scope and provisions. ANSI is a broad-based federation of some 150 technical societies and trade associations, and some 2,300 company members. Some 10 to 12,000 engineers, government officials, and representatives of various national groups participate in the development of standards under ANSI aegis.

The generative process begins when some knowledgeable party, corporate or professional, suggests a need for development of a specific standard. If the request is appropriate, ANSI searches the field and if it does not find an existing standard or someone already working on the subject, the need is passed on to the Member Body Council, who either finds an organization to work on it directly, or assigns it to one of 18 Standards Boards, of which the Nuclear Standards Board is one. The board in turn finds an organization, an appropriate standards committee, or an *ad hoc* committee to do or oversee the actual preparation. When the standard is completed, it is returned to the Board for letter ballot to Board corporate members and subsequent approval or disapproval. The ANSI catalog, issued annually, lists all the approved and available American Standards, including almost half a page of nuclear standards.

The Nuclear Standards Board

ANSI's Nuclear Standards Board has established 12 working standards committees to cover the broad range of nuclear activities. The 12 areas covered are: Basic Materials and Testing; Terminology, Units and Symbols; Radiation Protection; Transportation; Methods of Control; Criticality Safety; Design Criteria; Instruments; Non-Medical Radiation Applications; Medical Applications; Reactor Plants and Maintenance; and Atomic Industry Design, Construction, and Operation (other than reactors). Each of these committees is sponsored by an appropriate organization, such as ASTM, AIF, ANS, IEEE, NBS, ASME, AIChE, etc., and chaired by men from Battelle Northwest, Westinghouse, Los Alamos, Dow, Sargent and Lundy, Underwriters Lab, Argonne, etc. (The committee on Criticality Safety, for instance, is sponsored by ANS and chaired by Dixon Callihan, formerly of ORNL, now in charge of critical experiments for Y-12.)

The work of these several committees over the years has resulted in the development and approval of some 36 nuclear standards, one of the most fundamental of which, and closest thing to a real dictionary, is Nuclear Standard 1.1, the Glossary of Terms in Nuclear Science and Technology. It's surprising how subjective nuclear terminology can be: how people understand a given word or phrase to mean quite different things. N1.1, revised in 1967, was compiled to alleviate this problem. Chairman of the subcommittee in charge of the Glossary was Lawrence Dresner, of Neutron Physics Div., ORNL.

Progression

As I have indicated, progression of standards from inception to approval is often excruciatingly slow, especially as viewed from the pace of today's technological advances. The NSB's Special Committee is the gadfly for nuclear standards. We check on the progress of the work within each committee prior to each meeting of the NSB Executive Committee (eight to 10 times a year) and report all progress (or non-progress) at the meeting.

A recent report by Committee N-16 (Critical Safety) is a case in point. This is one of the more expeditious committees, and I cite it just to give a general impression, not for detail. The first of their areas of standards, for fissionable materials outside reactors, was surveyed in 1958, finally assigned in 1963, and approved as a standard in 1964. In May 1967 a revised draft was prepared, it was made available for comment the following January 1968, finalized in June, approved by the generating group in August, submitted to the full committee (ANS-8) in November, approved by them the following March (1969), submitted to the NSB by letter ballot in May, finally approved in August of 1969, and is now in press.

Nuclear Instruments (Comm. N-42) and the progression of its standard for test procedure for Geiger-Mueller counter tubes is another example. Admittedly this has a low priority, but Draft I was completed in 1967, II in 1968, III in 1969, and submission to the Board for approval is scheduled for later this year, barring unforeseen difficulties. Even the committee's highest priority item has problems that will hold it up as an ANSI standard for nine to 12 months. Altogether, the 12 nuclear committees have some 200 standards activities in progress, including the charter responsibility of re-evaluating current standards no more than five years after each approval.

Generally speaking, some three to four years of effort are required to bring a standard from inception to approval. This is primarily because the work is done on a volunteer basis at the will, or at least the forbearance, of the corporate author. The NSB is currently plugging for a system of three- to four-day, or even one-week periods of intensive standard-writing activity on the part of high-priority committees.

The effectiveness of such a procedure, where in effect full-time effort is made available as necessary by a number of qualified personnel, is shown in the rapid progress of the so-called RDT Standards. AEC's Division of Reactor Development and Technology, because of the urgent need for standardized methods and equipment for AEC-owned reactors and other nuclear projects, in February 1967 initiated a million-dollar-a-year standards-writing program at ORNL under the direction of M. Bender, director of General Engineering Division, and at the Liquid Metals Engineering Center at Atomics International in Canoga Park, Cal. This effort has resulted, after two years, in the publication last spring of some 70 tentative standards, mostly modified ASTM standards of a materials type. An additional 120 or so activities in methodology, instrumentation, and mechanics are now in progress. These standards apply only to AEC-owned facilities, but their very existence demonstrates that standards can be developed speedily if someone—government, industry, association—is willing to foot the bill. They also demonstrate that government can and will develop industry-wide standards, probably enforceable by law, if industry fails to do so. Copies of the current RDT Standards Index are available in ORNL's research libraries.

Although the level of activity of each of the 12 ANSI committees is uniformly high, in many instances accomplishments in the form of approved standards are relatively low.

Standards Compilations

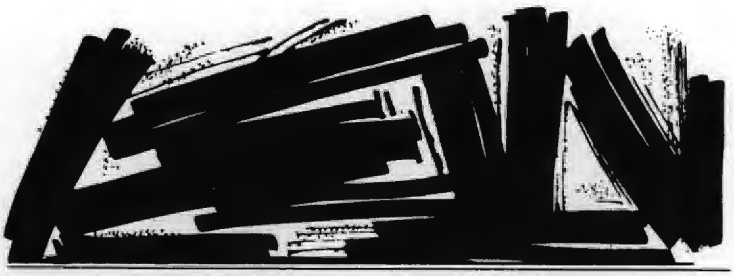
Another major function of the NSB Special Committee, in addition to acting as gadfly, is to prepare annual compilations of both U.S. and foreign standards. This is done through the publication facilities of the Nuclear Safety Information Center. The current U.S. compilation is ORNL-NSIC-57, and includes listings by generating organizations of all nuclear standards activities in this country known to the committee, from the Air Pollution Control Association through ANS and ANSI to the U.S. Post Office Department; 39 organizations are listed in all. In addition to being listed by organization, standards titles are also listed by key word in context, or the familiar KWIC index.

ORNL-NSIC-63 is the current Compilation of National and International Nuclear Standards (excluding U.S. activities). This compilation includes standards from 19 countries and 13 international organizations, like IAEA, ICRP, Lloyds, United Nations, etc. Both of these publications are available in the ORNL libraries.

Summary

ORNL's Nuclear Safety Information Center, and the concomitant *Nuclear Safety Journal,* are also important cogs in the standards wheel, since they serve to keep the nuclear community informed on current happenings, problems, and solutions—all essential to the development of standards.

The general topic of standards is one that doesn't inherently generate great enthusiasm. But the fact remains that it is an essential area of activity, and one that is liable to be preempted by governmental fiat if those of us who are capable and interested let it go by default. So if and when you're asked to serve on a standards-generating group or committee, don't point the finger at somebody else—accept the job and the responsibility, and let's get it done.



BOOKS

By Alex Zucker

IN PRAISE OF CITIES

The Economy of Cities, by Jane Jacobs. Random House, New York (1969). 268 pages, $5.95.

SOME BOOKS SPEAK TO YOU FROM THE first sentence. At once a bond is forged between reader and author, a mysterious bond of understanding, almost as if you had met an immensely sympathetic person with whom you can spend hours in lively conversation. The book tells you things, but it also elicits thoughts from you, and the feeling is that you are both at your best: the author and the reader. Such a book is Jane Jacobs's "The Economy of Cities."

People in cities, and only in cities, are responsible for all of mankind's advances. That is a premise of the book, and Mrs. Jacobs goes to considerable trouble to develop it. According to her all invention takes place in cities, and the peculiar combinations of commercial and technological innovation that produce wealth can only arise in cities.

Even agriculture was invented in the cities. Lest this startle you, Mrs. Jacobs recalls as an example the near-starving condition of rural France in the 9th century. Agricultural techniques well known to antiquity had been lost, metal was extremely scarce and used only for arms. The richest soil in Europe would not feed even a sparse population. The first sign of rebirth was the appearance of small cities where agriculture was essentially reinvented on small plots surrounding the city walls. Only later was it exported to the countryside. To be sure, conditions for reinvention need not be the same as those which led to the original development, but restraints of this sort are cast aside by the author who has a bookful of ideas to convey and who cannot stop and examine each of them critically.

Throughout the book theses are presented at headlong speed, passionately espoused or rejected, but rarely examined in depth. This makes the book highly personal, and because Mrs. Jacobs is an exceptionally intelligent person, the greater part of her ideas is fascinating and valuable.

The quest of the book is set in the first sentence: ". . .why some cities grow and why others stagnate and decay." From this point on, we are caught in a rush of ideas presented with a freshness and enthusiasm one rarely meets in works on economics or urban problems. (It is clear that Mrs. Jacobs is in love with cities. The messier, the more jumbled, irrational and chaotic they are, the more she likes them.) There is a description of two contrasting 19th century English industrial cities: Manchester and Birmingham. Manchester, the seat of then the world's largest and most efficient textile mills, seemed the very model of an immensely productive, single-industry city. Birmingham on the other hand lacked any large industry: instead, within it were thriving hundreds of small manufacturers, each trying to survive in an unorganized and competitive economy. The moral soon follows: as soon as other countries can build textile factories, Manchester stagnates and becomes the blight of the Midlands; Birmingham continues to grow because its versatile economy can branch out vigorously into new areas—electrical and automotive plants, for example. Birmingham prospers culturally as well as economically while Manchester shrinks in importance and in wealth.

How is it done? What are the conditions that make some cities grow and prosper while others never start—or stagnate after an initial growth period? Mrs. Jacobs has a theory which is best illustrated by an example. Tokyo at the end of the last century was a large city and a great importer of bicycles. As these bicycles broke down, repairs needed to be made, and many small repair shops sprang up all over the city. Some of the shops began to make bicycle parts rather than import them. Soon entrepreneurs began to manufacture entire bicycles by subcontracting various parts to this or that shop that had become expert in making it. So, a large bicycle industry was created in Tokyo. The money that was previously needed to import bicycles now was in part used to import raw materials, with a surplus left over to import new things—in this case, more food from the Japanese countryside. Eventually the suppliers of the bicycle industry became exporters in their own right, and what started as a proliferation of small repair shops ended as a miniature industrial revolution. That is the process. New work is added to old work, in this case making parts was added to repairing, and imports are replaced by indigenous manufacture. If then the local suppliers to the growing industry themselves become exporters, we have multiplied economic growth far out of proportion to the initial developments. Contrast this with a colonial development: a bicycle plant could have been opened in Tokyo by a foreign manufacturer. But any profits from it would go back to the mother country, and suppliers to the factory could never become exporters on their own. Result: economic exploitation rather than explosion.

Another example concerns Mrs. Ida Rosenthal, a New York dressmaker in the early 1920s. She decided that her dresses would display the ladies' figures more flatteringly if these figures were first cunningly moulded into more attractive forms. So she invented the brassiere. (Did you know that the brassiere was such a recent invention? I always thought that it was given to mankind by Prometheus, who lifted it from Hera's boudoir, and that this was the origin of his chronic liver complaint. But then shattering myths is Mrs. Jacobs's forte.) Soon the demand for brassieres spread from Mrs. Rosenthal's customers to other ladies who wanted to keep up, the dress business was abandoned, Maidenform was born and the brassiere industry started. Mrs. Rosenthal's suppliers of materials, elastic, fasteners, as well as companies advertising the new product, became exporters in their own right, and another economic miniexplosion was under way.

Now it is Mrs. Jacobs's point that only in cities can such economic growth take place, because only there can one find the many ancillary suppliers and services which make a new business venture practical. And it must be a very special sort of city with many small independent enterprises that are not locked into an economic behemoth. The company town is anathema to Mrs. Jacobs; you can practically feel the contempt she has for such a city, born at the call of a single economy and doomed to die with it, sooner or later. Starting new work is an exceptionally risky and highly inefficient process. That is why it arises from small businesses, since large corporations cannot move quickly and believe in efficiency above all else.

One can classify work in cities as "basic" if it is exported and "non-basic" if it is for the city's own economy. For example, basic work in Bessemer, Alabama, is steel; non-basic is a shoe store. A fascinating comparison shows that for every ten basic jobs the number of non-basic jobs in a selection of American cities is as follows:

New York	21
Cincinnati	17
Detroit	12
Albuquerque	10
Oshkosh	8

The conclusion is that the larger, more vital a city, the more purely internal work is there to do. In economic terms this implies a healthy city, although such cities are now, and always have been, overcrowded and smelly, as well as being the seat of the most virulent and perplexing social problems.

Much of the book deals with elaborations and illustrations of Mrs. Jacobs's theory. But there are many wonderful insights sprinkled throughout.

For example, Mrs. Jacobs challenges the whole anthropological fraternity when she maintains that cities did not first originate as concentrations of population in a completely rural agricultural so-

"...overcrowded, dirty...yet...the well spring of human creativeness..."

ciety. Quite the contrary, she maintains that cities came first, organized around trade, and that they invented animal husbandry and agriculture as new work which was then exported to the countryside. One of the most fascinating sections of the book describes the imagined birth of mankind's first city, New Obsidian, in a neolithic civilization.

There is an interesting observation that all the inquiries into the "causes of poverty" are doomed, because poverty has no cause. Only prosperity is caused, and, you guessed it, prosperity is caused by adding new work to old, replacing imports, etc., all in large, malodorous, inefficient cities. The analogy is made that poverty is the uncaused absence of prosperity, in the same way that cold is not caused, but the absence of thermal energy. In the same section, Mrs. Jacobs tilts with the population controllers, or at least with those who blame population density for all imaginable ills, and plan to cure them effectively by birth control. Many illustrations are brought to bear on this question. One of the most telling is the example of Ireland where the population dwindled from a poverty-stricken nine million in the middle of the last century to an equally impoverished three million a hundred years later. Or consider underpopulated Colombia, enormously rich in natural resources, and its people immeasurably poorer than highly populated, resource-poor Western Europe or Japan. The point is that human society cannot be managed like a herd of cattle on a piece of grazing land. If the cattle are too lean, reduce their number and they will fatten up. People thrive economically only in extremely dense populations—in the cities.

So much we hear and read these days is unrelentingly depressing. Unwittingly we seem to have wandered from the sunshine of productivity and wealth into the oppressive gloom of city-bred problems in our environment and our social structure.

"The Economy of Cities" does not exactly point a clear path out of our troubles, but it does remind us that it was ever thus. Cities have always been overcrowded, dirty, and unfit for the enjoyment of a tranquil life. Yet they have also been the well spring of human creativeness and the source of our economic prosperity. And because it helps us to understand how cities work, what makes them at the same time sublime and unbearable, this book is essentially an optimistic one; its conclusion is a faith in cities.

Fred O'Hara is currently on leave from his position at the Laboratory as a technical reports analyst in the Technical Information Division to work toward a doctorate in communications at the University of Illinois. He holds a bachelor's degree in chemistry (Boston College) and a master's in technical writing (Rensselaer Polytechnic Institute). At Illinois, he is specializing in printed mass communications, with a minor in library science. His work at ORNL has included the annual updating of KWIC index of the Laboratory's scientific literature contributions. O'Hara has published papers on information theory, on the communication of scientific findings, on advanced concepts in information storage and retrieval, and on copyright law. The following article is a shortened version of a talk presented to the American Chemical Society last spring in Minneapolis, co-authored by R. B. Parker, also of the Technical Information Division.

A Glimpse into the Global Village

By F. M. O'Hara, Jr.

THE MEANS OF EXCHANGING technical and everyday information will be altered in the coming decades by such advancing technologies as electronic data processing, microimaging, and reprography, as man's society with its scientific segment shifts from a culture relying heavily on books and the printed word to one in which the principal means of communication is electronic and in which the ultimate storage place for all knowledge is the electronic library. Today technology-transfer efforts take, primarily, one of three modes: face-to-face oral communication, disseminating and archiving information through the journal literature, and selective retrieval of information from archived material. Each of these processes will be directly affected by the information-handling technology now developing.

Increase in Specialization

Studies have been made on the development of magazines in competition with other mass media, and the effect on radio of the phonograph record industry. The findings were that in neither case did the older medium die off under the impact of new means of entertainment. Rather, it changed its nature, structure and appeal, and to a radical extent. Fundamentally, the audiences for each of these media became segmented or fractionated. There was a drift in appeals toward selected, like-minded audiences within the total population, and the market was split up among the competitors and widened considerably in the process. The mass media, except television, now address themselves to ever more clearly defined targets differentiated on the basis of cultural interests, leisure-time activity, etc. Magazines are no longer the Saturday sheets that told all men all things, but rather slicks intended to sell to hot-rod buffs, gamecock trainers, or do-it-yourselfers. Records no longer purvey solely potted palm music but all types. Radio programs are not endless strains of music to ho-hum through the day by, but are segmented into programs of hard rock, classical, mood music, jazz, folk, and the talk shows, with the distribution of these being some function of the constitution of the available audience.

This segmentation has occurred in the technical literature also with the all-science proceedings devolving first into journals and societies for the individual physical, life, and pure sciences and then into thousands and perhaps hundreds of thousands of publications about subgroups (organic chemistry) and subsubgroups (physical organic chemistry) and subsubsubgroups (physical organometallic chemistry).

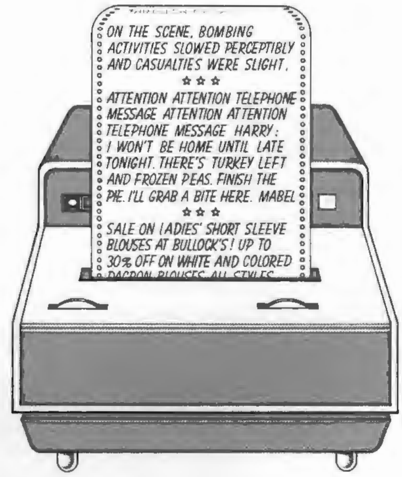
It is only reasonable to assume that this fractionation of audience and subject matter will occur to television also as the transmitting equipment and channels become cheaper, more available, and more numerous, especially with cable television and orbiting satellites taking more of the economic load of transmission off the local-affiliate stations, allowing the stations—or more bluntly, forcing them—to utilize their resources in originating programs. This will result in a radical change in the economic base of local television broadcasting, making such stations more acutely aware of the needs of their viewing public, a result that legislation such as the Communications Act of 1934 has failed to achieve.

Other advances in technology undoubtedly will furnish some form of verbal feedback from the TV audience. When this happens it might be possible to supplement scientific-meeting attendance with television coverage that includes audience participation. Reprints of papers could be transmitted with the broadcast and facsimiles reproduced at the viewing site. Thus audio and video presentation of a paper, questions by the audience, and distribution of printed copies of the paper would all be carried out over the airwaves. Indeed, it should not be too long before AEC invisible colleges can meet visually and orally over an FTS-like system.

DEFCU

In fact, such a network can conceivably evolve into a universally available system for home use. It could be called a Domestic Electronic Facsimile-Communication Utility, or DEFCU, and it could effectively incorporate, supplement, or supplant our present-day universal communication media: the postal system, magazines, newspapers, AM and FM radio, movies, television, and telephone. It would provide services hitherto unneeded and unavailable but now demanded for a growing, farflung, highly inter-active citizenry. Electronic communication must supplant costly transportation wherever possible in an increasingly expanding population. Technical and legal aspects of utility installation and regulation are now being examined in a new light with the advent of cable TV and the computer utility, and much of what is coming out of these investigations and experiments will determine the commercial viability of more futuristic information networks such as the DEFCU.

Therein is embodied a systems idea in which magazines and newspapers will be broadcast over the airwaves or through cable networks and reproduced on an electromechanical printer in the subscriber's home, thus obviating the waste of time and money of printing and delivering the product.



"... would reach the people who aren't home much..."

Other uses of the system will allow drawing upon the resources of a microfilm library by dialing in a request to a central depository and receiving video transmission and/or hard printout automatically. There will also be the facility for sending facsimile copies over the wire from any one subscriber to any other, a capability already referred to as the electronic mailbox. Indeed, use of the system for written communication automatically transmitted during the night when system use is low may be a solution to the problem of our shackled and overburdened Post Office.

DEFCU would be capable of direct integration into the already existing telephone and broadcast networks of communication. Facsimile newspapers would deliver news on schedules independent of press deadlines; magazines would not need U.S. Post Office subsidy; and person-to-person communication would reach the people who aren't at home very much by leaving hard-copy messages.

One problem to be grappled with is the method of printout. Mechanical printers are too large, noisy, and slow. Electronic displays are not permanent. One method envisioned last year by scientists at RCA was to reconstruct signals on photosensitized paper with a light beam, employing paper that is reusable, like magnetic tape. This material, however, is expensive, which would discourage the saving of messages. On the other hand, if the ordinary light source were to be replaced by a laser beam, and the paper with ordinary paper, the economic problem would be solved: the laser could be used literally to burn the image on the surface of the paper. If the density and thickness of the paper were optimized, and the power of the laser matched to the properties of the paper, both sides of the paper could be used in this fashion. Such problems as those of combustion control could be handled by chemical impregnation or coating with a plastic that is made translucent to the laser's energy.

Scientific Applications

Now consider a community of users of the periodical scientific literature, all interested in different, perhaps overlapping facets of their field, and served by a central library that subscribes to all the journals of interest to the members of the community. Although this library contains all the periodical literature they might need, most of the members of the community, for convenience, also have personal subscriptions to the one or two journals that cover most closely their area of interest and to which they would therefore have the most frequent reference. This system still has two major drawbacks. First is the monetary waste in the duplication of subscription effort between the individual and the library and the individual and other members of the community. Second, the individual is subjected to overinformation; he very likely will not be interested in all the contents of any one journal, but will pick and choose among the articles. This inundation of superfluous information and the waste of subscription funds could be eliminated while maintaining the convenience of personal hard copies of pertinent information if

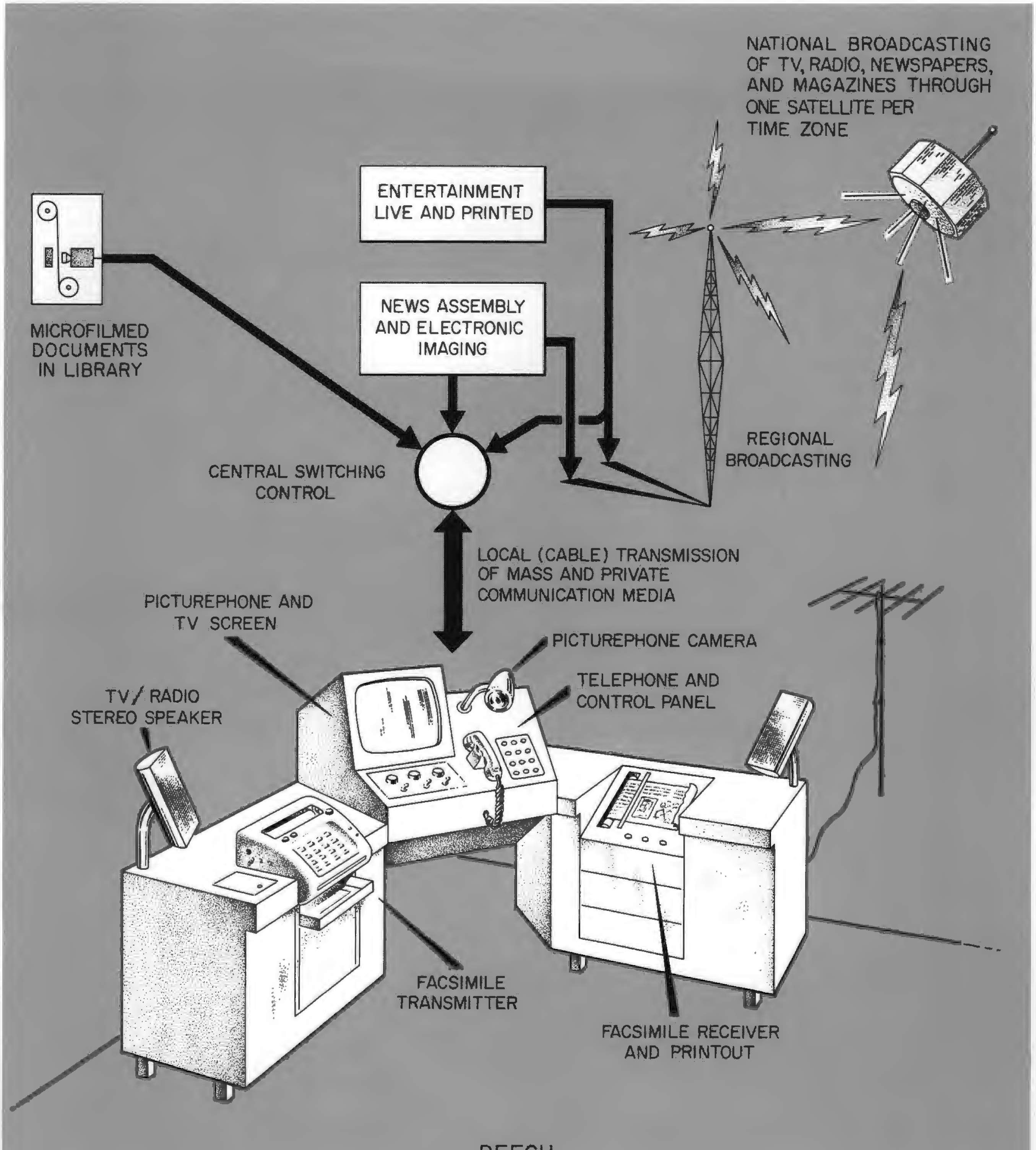
- the library were the only recipient of the periodicals
- in microform
- from which titles and abstracts would be culled and distributed to the serviced community
- who would scan this title and/or abstract list
- and return to the library a notice in machine-readable form
- containing the identity of the requestor
- and the items of interest,
- which form would be the input to a machine controlling an optical system
- that located,
- imaged (reproduced),
- addressed to the requester,
- and mailed hard, full-size copies of the requested literature.

Given some advances in the state of the art, videotape recorders might find use in the storage and retrieval of documents. A hybrid between a videotape recorder and a digital computer could take a single-scan television picture of a document, store this video image on magnetic tape, and write digital descriptions of this document on an adjacent segment of the tape. In the retrieval mode, the digital portion of the device could scan the digital signals, searching for the desired combination of key words or other indicators. When it found the right combination, the tape would be slowed, the video signal read from it and projected on a monitor screen. The document could then be read and evaluated by the researcher, and if considered pertinent, could be reproduced then and there in hard copy. Such a system could operate more effectively if a buffer file were kept of the key words and index numbers of each document. The results of the keyword search would then be a list of the index numbers of the documents that might be pertinent. After these were sorted, a single pass of the video/digital device scanning the index numbers could extract the video images of all the documents to be examined for pertinence.

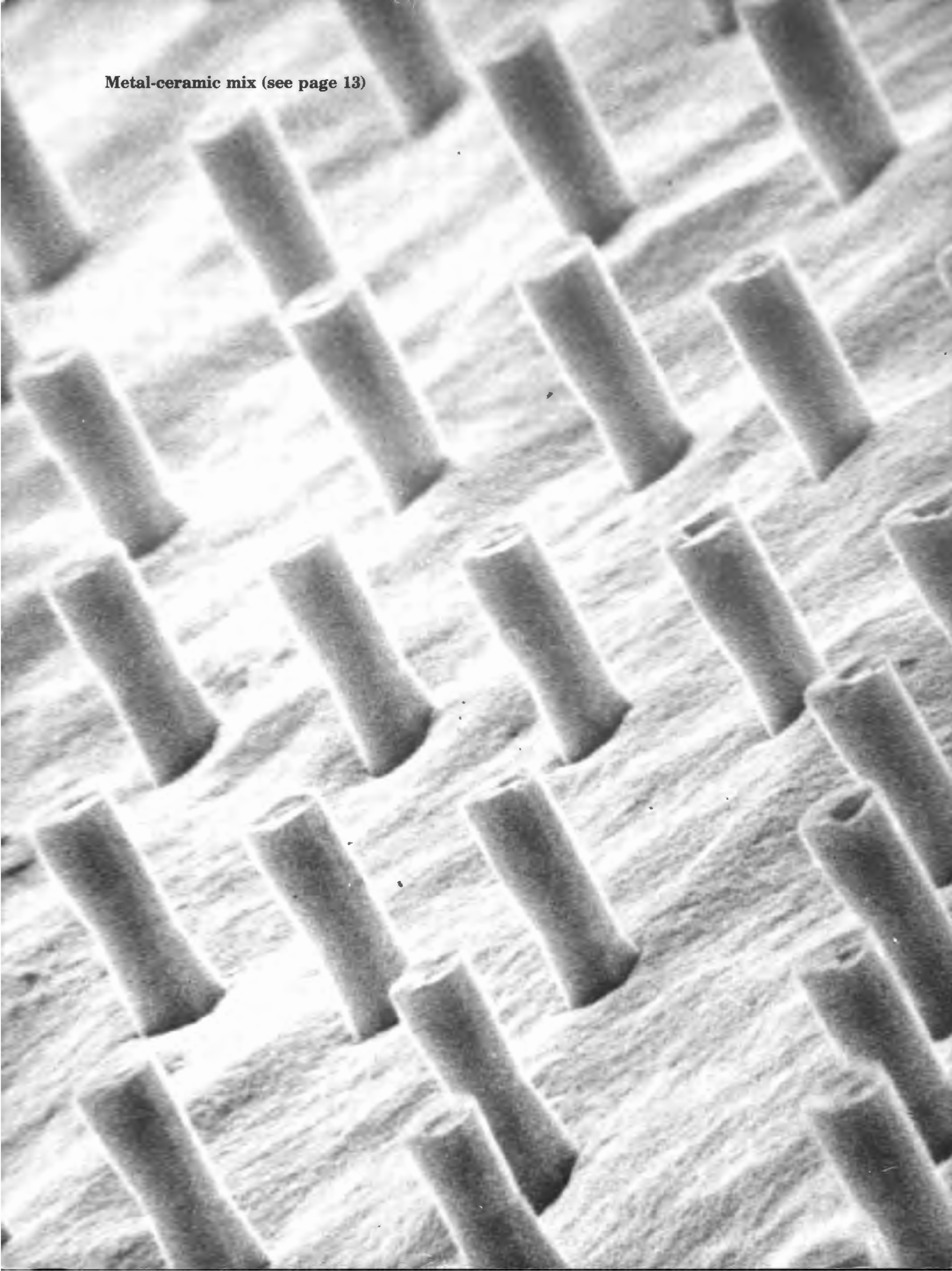
A laser-television system has been described that has a vertical resolution of six scans for nine-point type at a distance of 50 feet. This would solve any problem of resolution in producing a video image of a printed document. Commercial monitoring equipment is already available having over 1,000 scan lines per picture (compared with the standard U.S. TV screen resolution of 525 lines per frame) and requiring 20 MH band width. Although there are no video tape recorders that can record and play back this band width, slow-scan TV, which increases the number of scan lines with fewer frames per second, could be used to overcome this limitation.

These examples offer some idea of the stunning advances we have made and may further expect in communication technology. In two human lifetimes Americans have gone from pony express and packet-ship transcontinental transportation of the hand-written word to instantaneous transmission of television pictures from the Moon and digital data from Mars. Application to and utilization of this technology in day-to-day life and professional activities is inevitable. At the same time that we are being mesmerized by the fascinating capabilities thrust upon us with such rapidity, we have to admit that the hitch is not in technical feasibility but rather in determining how best to apply the machinery to human requirements. And so it will be important to consider all fashions of configurations of communication devices, and weigh each for its ability to aid the advancement of technological and social man.

In other words, man must be very careful in fashioning the systems that will in the future fashion him.


NATIONAL BROADCASTING OF TV, RADIO, NEWSPAPERS, AND MAGAZINES THROUGH ONE SATELLITE PER TIME ZONE
ENTERTAINMENT LIVE AND PRINTED
MICROFILMED DOCUMENTS IN LIBRARY
NEWS ASSEMBLY AND ELECTRONIC IMAGING
REGIONAL BROADCASTING
CENTRAL SWITCHING CONTROL
LOCAL (CABLE) TRANSMISSION OF MASS AND PRIVATE COMMUNICATION MEDIA
PICTUREPHONE AND TV SCREEN
PICTUREPHONE CAMERA
TELEPHONE AND CONTROL PANEL
TV/ RADIO STEREO SPEAKER
FACSIMILE TRANSMITTER
FACSIMILE RECEIVER AND PRINTOUT

DEFCU


Metal-ceramic mix (see page 13)