sion. Companies with different technologies became associated. Individual companies were expanded into large corporations with several divisions specializing in the several fields. With the arrival of missiles, atomic weapons, and space vehicles, research groups were established within the aerospace corporation, first made up of engineers and applied scientists, later including basic research scientists in the life sciences as well as the physical sciences. The development task became one of dealing with many systems, subsystems, and components, integrating them with extension of the systems concept to include all aspects of design, construction, and use. Even field maintenance, training of operators, and consideration of the real objectives and values of the whole development enterprise became an activity of the corporation. As the scope and size of projects became very large, even corporations had to be associated to provide the required resources.

Formation of a Team

In the space program it has been necessary to go still farther, to assemble a combined team of industry, government, and university, comprising hundreds of thousands of persons contributing to a single objective. Relations between supplier and customer grew to an intimate partnership. New institutions such as the Communications Satellite Corporation have been invented. Others will undoubtedly follow.

The university must be equally flexible and adaptive to meet its responsibilities and opportunities in the next century. Where does this leave the dynamic quality of science, the traditional values of pursuit of excellence, freedom of inquiry, preservation of creativity, and the support of the unconventional new ideas, particularly those of young scientists? We must be concerned to preserve these essential freedoms which have led to progress of the university in the past.

Paradoxical as it may seem, I believe that these values may not only be preserved but may even be strengthened within the larger framework of increased scope which can provide a sounder human motivation, bring allocation of increased resources, provide the satisfaction of great accomplishment in terms of human goals, and a sense of a community of interest with all mankind. If you will take the time to discover what is now going on in the exploration of space, you will find a free association of individuals, each with complete freedom of individual choice, in the largest and most challenging venture of man, the search for knowledge of his environment and the application of this knowledge to his benefit. In this group of several hundred thousand people you will find innumerable examples of the pursuit of excellence from the renewed pride of the workman in his handicraft, to the intellectual effort of the scientist to analyze and observe. You will find mainly young men, unafraid of large problems or rapid change. You will find the unconventional idea being given attention. The university and the university scientist must and will adapt to the age of space exploration.

Parenthetically, in closing, the National Academy of Sciences, born of the university and bearing the marks of its parentage, must also adapt to the environment of science as it exists today and to the environment of its second centennial. I have been pleased to see the steps being taken by the Council under the leadership of President Seitz to play an appropriate role in the formulation of science policy and in giving advice to the government on the potential contributions of all science, whether government, university, or industry, and whether "big" or "small."

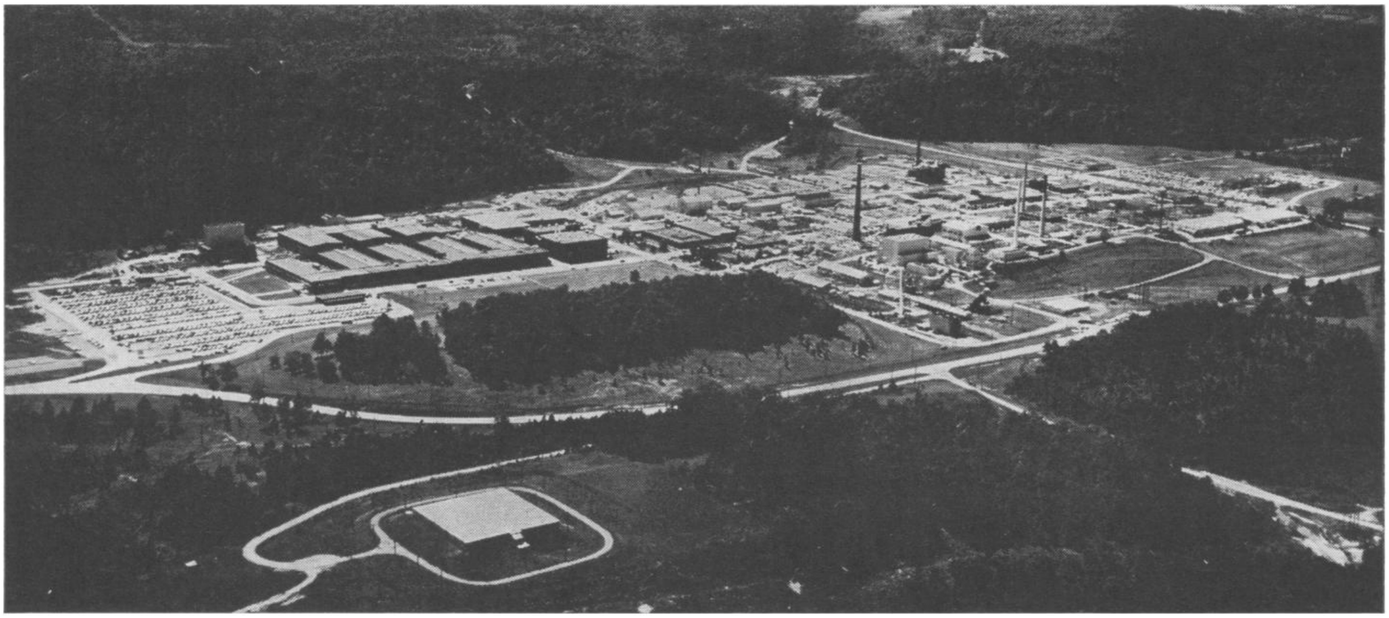
Oak Ridge National Laboratory: Aim Is Change along with Growth

Oak Ridge National Laboratory has a name that needs explaining. Although its facilities are government-owned, ORNL is not a federal laboratory staffed by civil servants but, rather, is operated under contract by a major industrial corporation. Furthermore, for more than two decades the laboratory has concentrated on research and development work relevant to the mission of its sponsoring agency, the Atomic Energy Commission. Increasingly, however, ORNL is going "national" in the sense of carrying out R & D activities aimed at solving problems beyond the boundaries of the AEC mission, as narrowly defined.

ORNL has a mixed academic-industrial ancestry. It grew from the original research facility—known as X-10—built in 1943 shortly after the Manhattan Engineer District settled on Oak Ridge as the site for major plants for separating uranium-235. The new X-10 was essentially a pilot plant designed to extract very small quantities of plutonium to prove the feasibility of big plutonium-producing reactors scheduled to be built at Hanford, Washington.

In inspiration and to some extent in staff, the facility was really an extension of the University of Chicago Metallurgical Laboratory. The University of Chicago was contractor, but engineers of the du Pont Company, which had been made contractor for the Hanford works, collaborated in the design of the graphite reactor and the radiochemical pilot plant which were X-10's main elements. Old hands recall that, because of du Pont experience and the unknowns involved in the project, X-10 was laid out like an explosives plant.

Shortly before the end of the war, the contract for operation of X-10 was transferred to the Monsanto Chemical Company. The name Clinton Labora-



Oak Ridge National Laboratory

tories was given the operation, and, as the name implies, the lab pushed into broader fields of nuclear research. Reactor development and basic research became integral parts of the lab's activities. In this same period the laboratory was given responsibility for producing radioisotopes for scientific and therapeutic purposes.

The years immediately after the war were vital to the lab in terms of both decisions and personalities. For about 16 months after May 1946, Eugene P. Wigner, on leave from Princeton, served as director of research and development. Reactor development was one of Wigner's interests, and he encouraged work in this field. It was also during Wigner's tenure that a separate division of biology was established and Alexander Hollaender, a radiation biologist then working in Washington, was named director.

Because security wraps still shrouded the nuclear sciences, the transmission of knowledge and techniques to the universities was a considerable problem, and the lab at Oak Ridge in this period responded by setting up what in effect was a school for atomic scientists. Director of this Clinton Laboratories Training School was Frederick Seitz, now president of the National Academy of Sciences. The school operated for only about a year, but it claims as alumni an impressive number of people who were to play important roles in the development of nuclear energy, both in research and, as in the case of Admiral H. G. Rickover, in engineering and administration.

Not much later came the formation of the Oak Ridge Institute of Nuclear Studies. ORINS, as it is called, was established in October 1946 as an organization to institutionalize cooperation between a group of southern universities and the laboratories in areas where mutual benefits could be gained. There were 19 member institutions when the cooperative arrangement was signed, and there are now more than twice that many. ORINS now administers more than a score of programs of research and education in nuclear science. The programs affect every level of education, from the high school to the postdoctoral, and some are international in scope.

A change in the name of the organization to Oak Ridge Associated Universities is scheduled to take effect on 1 January. The change is intended to reflect a reorganization which will make it possible for member institutions to pursue cooperative research and education programs outside the category of nuclear energy. ORINS will be incorporated in the new structure.

ORINS was established in part to enable the Oak Ridge lab to play a role in the scientific and cultural development of the South. The move anticipated current concern over the results of concentration of federal research funds in a few areas. And the ORINS cooperative arrangement can be viewed as a model for subsequent, similar efforts.

In this same period the laboratories passed through a time of troubles. At war's end, the laboratories' staff was reduced by about a third—to approximately 1000—by the departure of many scientists for their universities. The key question, however, was whether it was desirable or even possible to operate a productive major research center away from a conventional big city-university-industry setting. The events of the period deserve to be untangled by those writing the history of the AEC. But those at Oak Ridge who lived through the crisis remember that a committee headed by Nobel laureate I. I. Rabi recommended that the laboratories be uprooted, and that even among people at Oak Ridge, what one old hand calls the "Rabi syndrome" was very strong. Those who held out for Oak Ridge argued, among other things, that the momentum built up in the lab's programs would be lost, and that the region would be deprived of an asset which would grow increasingly important.

At about the same time there was difficulty over the contract. Monsanto apparently visualized the laboratories as part of its own operations and wanted to move them to St. Louis. When negotiations failed Monsanto stepped out and the University of Chicago returned as contractor pro tem.

In December 1947 a decision was made to concentrate work in reactor technology at Argonne National Laboratory. This meant a loss of personnel and something of a blow to morale at Oak Ridge. But Oak Ridge was instructed to concentrate on chemical technology; isotope production; basic research in chemistry, physics, biology, and metallurgy; and the fostering of regional cooperation. The life-or-death issue for Oak Ridge was, in effect, decided.

Then in the following March the matter of a contractor was settled. The Carbide and Carbon Chemicals Corporation (later Union Carbide) became contractor for the labs, as it was for the two other major plants. It was at this point that the Oak Ridge National Laboratory got its name.

The decision on ORNL was really a concomitant of the postwar decision, ratified by the new AEC, to create a network of permanent research centers to continue development of both military and peaceful uses of the atom. Maintaining American preeminence was a recognized objective.

These centers range from those involving a relatively small number of scientists and graduate students at universities working on projects supported by the AEC to major installations devoted entirely or largely to AEC projects. There are about a score of these major centers, which the AEC calls "commission laboratories." Among the best known of these is a group called "multiprogram laboratories" because they are engaged in a wide variety of R&D activities. These are ORNL, Argonne National Laboratory; Brookhaven National Laboratory; and the Ames, Lawrence Radiation, and Los Alamos Scientific laboratories. Except for Oak Ridge, all are operated for the AEC by university contractors.

To achieve balance, these commission labs have been assigned different areas of specialization in R&D. This plan appears to have worked reasonably well, although there have been disappointments, duplications, and shifts in the interests of staff members which have resulted in discrepancies between expectations and results.

The long-range trend at ORNL, which started off with a strong orientation toward applied chemical sciences, has been a fairly steady growth in size and an expansion into physics and biology.

Presiding over ORNL for a good part of its development has been Alvin M. Weinberg, director of the laboratories since 1955. Weinberg, a physicist, worked at the Metallurgical Laboratory in Chicago during wartime, was at Oak Ridge at the end of the war, and stayed. In 1947 he became director of the physics division. Then, from 1948, he served as research director of ORNL until he was appointed director.

From some 2000 in 1949, the ORNL staff has increased to about 5000 today. About a third of ORNL manpower is employed on research and development work on all types of reactors, for use in everything from electric generating and water desalination plants to space vehicles.

Another third of the staff is engaged in fundamental research in physics, chemistry, and metallurgy. The remaining third is deployed in research in biology, health physics, production of isotopes, and education and training activities.

The biggest division, although in some ways untypical, is the biology division. During the war, biologists at Oak Ridge worked primarily on radiation safety, and a good many of them joined the exodus when the war ended.

When Hollaender came to Oak Ridge as director of the newly created biology division, he intended to try out some new ideas. A main concern was to be study of the effect of radiation on the genetic mechanism. Emphasis on microbiological and biochemical approaches was to be increased. And attention was to be given to three main questions: What are the long-term implications of radiation to man? What are the effects of internal (ingested) emitters of radiation? What is the lowest degree of radiation which has an effect? Hollaender feels that good progress has been made toward answering the first question, and that answers to the others are "in process."

New Blood

The biology division has a staff of 400. Of these about 150 are Ph.D.'s. Although the formal teacher-graduate student relationship of the university has been lacking in the lab, Hollaender has encouraged the infusion of young blood, and there are usually about 50 young Ph.D.'s on hand on 2-year postdoctoral fellowships. And two-way academic traffic between the division and the University of Tennessee in Knoxville seems to be growing.

Under Hollaender's directorship the biology division has developed something of a separate institutional personality. This in part is due to the division's having been established at the Y-12 plant several miles from the main laboratory site. The biology division's staff also tend to see their work as less mission-oriented than the work of most other divisions.

Hollaender's reputation is that of a firm and decisive administrator. As one senior researcher put it, "There's only one administrator. Everybody else is a peon." There are few titles, and whatever hierarchy exists seems to depend on the individual investigator's performance. Competition is encouraged, but it is expected to be with researchers working elsewhere. Biology staff members pride themselves on the division's being "more adventurous" than other divisions and say, for example, that a number of education programs taken over by ORINS originated in the biology division.

Management of the laboratories by an industrial corporation seems to be generally accepted as a fact of life by ORNL staff members. Perhaps the mixed character of the system, with Carbide setting personnel and administrative policies and providing fringe benefits and the AEC giving program direction, accounts for the fact that most staff members identify with the labs, which are likely to continue to operate, rather than with Carbide, which conceivably could cease to be contractor at some time in the future.

To scientists at ORNL, the rules governing outside activities seem to be somewhat stricter than those at most universities and more in line with government and industry patterns. ORNL staff, for example are not allowed to serve on the boards of companies engaged in work similar to the scientists' projects at the labs. Consulting is ordinarily limited to 12 days a year, and contracts for ORNL staff members' services are negotiated by Carbide. If the staff member gives an outside lecture on company time he is expected not to keep the fee. Patentable discoveries must be disclosed to the AEC.

On the other hand, government consulting seems to be encouraged, and policies on attendance at professional meetings and even on leaves for research elsewhere seem to compare favorably with university policies. The ORNL researchers, in addition, are relieved of the teaching and heavy committee duties which are the lot of most university scientists. Hollaender himself says he feels the fact that researchers at the industrially managed ORNL do not have tenure, as they would at a university, may well have a healthy effect on their enterprise as scientists.

One problem which concerns many responsible people at ORNL is that of maintaining the quality of work in what is now a very large research establishment. With more than 5000 professionals and supporting staff, the labs have the manpower resources to mobilize for major efforts in interdisciplinary research. But with 18 scientific divisions to be administered, a rigid bureaucratic structure could easily develop. In some divisions the staff has fallen into a civil-service pattern of the routine 8-hour day, which does not provide optimum conditions for scientific endeavor.

While the labs have been growing at an average rate of about 8 percent annually in recent years, many of the new arrivals work on new projects. In general there is relatively little turnover at the administrative or senior scientist level, and while most divisions are active, a few are what one administrator described as "over the hill."

Weinberg has been one who clearly recognized the need for rejuvenation and for maintaining vitality in a place like ORNL. A lucid and fairly prolific writer on science policy, Weinberg has been a leading advocate of giving the federal laboratories a greater role in science education (*Science*, 6 April 1962). He has also urged that federal laboratories keep deployed against the truly important problems facing the society.

In a state-of-the-laboratory talk at the end of 1964 Weinberg said, "during this period of stationary budgets for science, we as a government laboratory are particularly vulnerable to the perennial question: 'Why do we exist and what are we for?' " Weinberg went on to point out that a committeee had been established by the President's science advisor, and chaired by E. R. Piore, to review the functions and validity of the many hundreds of government research establishments. The AEC labs were omitted from the study, but Weinberg predicted their turn for scrutiny would come.

In his statement Weinberg identified five "central problems" facing society and said that ORNL is "at the forefront of the attack on each of these problems."

1) In pursuit of a source of cheap and abundant energy, concentrated work is being pushed on the thermal breeder reactor. And potentially even more revolutionary, although much more difficult, is the attempt at achieving controlled fusion—the ultimate jackpot of thermonuclear energy.

2) The increasingly serious need for cheap and abundant water has attracted attention to ORNL and the group associated with Philip Hammond in work on water desalination.

3) Research to meet what Weinberg calls "the problem of chemical and physical assault on the biological environment, and of cancer," is being expanded. Some $3.5 million in grants from the National Institutes of Health represent a kind of collaboration with other federal agencies which ORNL partisans hope will keep growing.

4) Since September 1964, Wigner has been spending about a week a month at Oak Ridge to head the ORNL Study of Civil Defense. An outgrowth of the Project Harbor study which was sponsored by the Defense Department and the National Academy of Sciences, the ORNL project is devoted in part to further examination of the thesis that a civil defense program, including blast shelters, is feasible. Because the study involves key social and political factors, the small Wigner group includes three social scientists, a new departure for Oak Ridge.

5) The change in ORINS should enhance ORNL's capacity to assist in the raising of educational and cultural standards in deprived or depressed regions.

In his statement Weinberg saw ORNL entering "a sort of Golden Age" as it followed the manifest destiny of the big national laboratory to attack big national problems.

—JOHN WALSH

Auto Safety: New Study Criticizes Manufacturers and Universities

One day next week, auto executives in Detroit will awake to find themselves confronted with a book that is likely to be the *Silent Spring* of traffic safety. Called *Unsafe at Any Speed*,* the book, by a young Washington attorney, Ralph Nader, describes in a straightforward way why it is that our cars are dangerous and how they could be made safer.

The manufacturers will howl, but his analysis is detailed, well-documented, and subtle. He provides an illuminating study of the 1960–63 models of Chevrolet Corvairs, whose handling characteristics were cited in over 100 damage suits against General Motors and also spawned a subsidiary industry—small supply companies that developed special stabilizing equipment for the Corvair. More important than the analysis of one-car accidents is Nader's discussion of "the second collision": what happens inside a vehicle when cars crash. Since shortly after World War II, a handful of scientists have been studying ways of "packaging" car occupants to reduce the hazards of collisions and have accumulated a good deal of significant data. But car-design reformers have consistently run into Detroit's preoccupation with styling and cost. Inventions developed independently—such as an energy-absorbing bumper—have often been dismissed or ignored. The result is a wide gap between what the scientists and engineers know and what Detroit produces.

Industry's attitude toward the proposition that cars could be safer is summed up in the quotation from a speech by General Motors president John F. Gordon in 1961, with which Nader begins his study. "The traffic safety field," Gordon said, "has in recent years been particularly beset by self-styled experts with radical and ill-conceived proposals. . . . The general thesis of these amateur engineers is that cars could be made virtually foolproof and crashproof, that this is the only practical route to greater safety and that federal regulation of vehicle design is needed. This thesis is, of course, wholly unrealistic. . . . The

* The book, subtitled "The Designed-In Dangers of the American Automobile," will be published by Grossman, 30 November, $5.95. The author is a graduate of Princeton and of Harvard Law School and was formerly a consultant to the Office of Policy Planning and Research, Department of Labor.