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THE NATIONAL LABORATORY AS A CONTRIBUTOR TO THE GOALS OF ENGINEERING EDUCATION*

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THE NATIONAL LABORATORY AS A CONTRIBUTOR TO THE GOALS OF ENGINEERING EDUCATION

First of all I would like to express my sincere thanks for your kind invitation to talk to you. I appreciate this honor especially from this group because in spite of the fact that I have many close friends among university professors, I never managed to overcome the awe I had as a freshman. My son-in-law, who became a professor only two months ago; you can see where this leaves me in the family.

I would like to outline to you some of the fields of common interest to national laboratories and engineering educators. However, before starting my subject itself I think it might be of interest to consider the chief subject of my talk: the national laboratory.

The multipurpose national laboratory is a relatively new phenomenon in the American scientific horizon. I am sure that you are aware of its beginning. The tremendous engineering undertaking, the development of the atomic bomb, required the hurried creation of completely new facilities in areas often quite remote from established industrial or educational centers. The government was not able to provide the necessary organizational framework and therefore these institutions were managed by large universities or industrial companies. People whose chief preoccupation was industrial development and management on one hand, and pure scientific research or education on the other hand were brought together to work side-by-side in what became perhaps the largest crash program in the history of mankind -- the development of the atomic bomb. The previously separate worlds of academia and the market place came thus in close contact with each other; scholars from universities such as MIT, Columbia, University of Chicago, University of California, etc. rubbed shoulders with staff scientists of large industrial companies such as General Electric, Union Carbide, DuPont, Eastman, etc. Even though the Manhattan Project was under the supervision of the Army, this symbiosis of educational institutions and industrial companies became its chief hallmark.

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During the war years there was no time for anything but the immediate goal of the project. Educational activities had to wait for more quiet times. There was a period shortly after the war when the very existence of these institutions created with such a tremendous expenditure of money was doubtful. The chief goal has been reached; this country was the sole possessor of the most awesome weapon of history and the glow of wartime solidarity prevailed for a while among the previous allies. In the absence of a patriotic call of duty and not having a compelling goal, the professors from universities and research managers from the companies had time to inspect more closely their prefabricated flat-top houses, standing in muddy streets without sidewalks and soon started an exodus back to their universities and industrial laboratories. After all, their houses were built for ten years (even though the government sold them to us 15 years later) and there was no compelling reason for them to stay; the physical embodiments of many such wartime crash programs did disappear without a trace in the past.

However, I think luckily for the country, this flight from the sites was checked. It became obvious that the weapons program had to be continued in order to maintain this country's leadership. Also, very importantly, new, still unexplored areas appeared: the peaceful application of atomic energy offered all the necessary excitement for engineering and scientific research and development and induced many of the wartime workers to stay on and even lured others to the sites. The magic of names such as Los Alamos, Hanford or Oak Ridge acquired during the war years was very helpful to recruit the needed personnel.

The new programs after the above-mentioned lull had passed aimed at the creation of new devices, touching many still unexplored parts of science and engineering and required the cooperation of people in a large variety of disciplines. All this helped to create the new concept, designated by the director of the Oak Ridge National Laboratory, Dr. Weinberg, as "big science". Big science tackles

problems that cannot be solved by isolated workers, no matter how brilliant they might be. Like building a bridge over a big river or operating a railroad system, this type of work requires the collaboration of many people and the investment of large sums of money.

The laboratories organized on this basis are a curious reflection of the university. They contain departments devoted to pure sciences, such as physics, chemistry, metallurgy, biology, etc. Very often, interdisciplinary fields, less intensively pursued at classical educational centers receive special attention. These pure sciences are supported by strong design-engineering groups and well organized centrally managed shops, making it possible to reduce efficiently into practice the theoretical concepts. It was a lucky coincidence that this new type of institution of thinkers and tinkers was named "national" rather than "atomic" laboratory. This all-encompassing name makes it possible to accept assignments beyond the strictly atomic areas and to tackle problems of national interest for which this quality of bigness is important.

During this period of reorientation the scope and motivation of the technical communities changed. Those who were there during the exciting war years were extremely proud of the part they played in the development of the bomb, rubbing in continuously this fact to new arrivals. I was in a good position to observe this when I arrived in Oak Ridge early in 1949 to work at the NEPA (Nuclear Energy for the Propulsion of Aircraft) Project. Most of my colleagues were veterans of various wartime projects who preferred to stay on rather than to return to more "civilized" sites. As time passed on, I managed to become an oldtimer myself and now, with more than 17 years in Oak Ridge, I, a relatively new immigrant to this country, can play the role of a Mayflower pilgrim when talking to new arrivals to our city. Of course, I cannot hope to impress our true nobility, the "43ers"; they actually consider themselves Indians.

It was quite logical that the early educational activities of the national laboratories were aimed to eliminate shortcomings of

the traditional educational system. These institutions needed new kinds of experts who were simply not available. This was due to the fact that many of the new specialties grew up in secrecy; very little was published in the open literature, even though the basic scientific principles were known. The field of reactor engineering did not exist; as a matter of fact, the University of North Carolina can claim to have initiated this new discipline. The Atomic Energy Commission was forced to establish a specialized reactor engineering training program, out of which grew the Argonne and Oak Ridge reactor technology schools. The program was later divided into two parallel curricula of reactor operations and reactor safety evaluation. An important feature of the school was the special reactor design assignment which occupied the last few months of the students' stay at the school. Groups of about 5 students were to prepare a design for an advanced type of reactor under the supervision of a senior laboratory staff member. They searched the literature, consulted with other laboratory engineers and came up with a design solution. Presentation of the results of this summer project became an important annual event attended by outsiders; several current successful reactor schemes are based on a report of ORSORT students.

For a long period the Oak Ridge School was a classified facility, while the Argonne School established within the framework of President Eisenhower's Atoms for Peace proposal had from the very beginning an international flavor. Many foreign leaders of national atomic energy programs received their initial specialized training at the Argonne School; since 1959 the Oak Ridge School was also opened up to foreign participants.

During the last decade the field of reactor engineering became recognized as a bona fide engineering specialty; several universities and schools of technology organized curricula leading to a bachelor's or master's degree. As there was less and less need to train specialists "in house", these schools have been discontinued as of last year. Even though these schools did not award a formal diploma, a

considerable prestige value was attached to the successful completion of the course, often reflected in promotions or employment offers.

The national laboratories took the initiative to train specialists in another new interdisciplinary field: that of health physicists. This profession is as old as reactors. Before Fermi's famous experiment on December 2, 1942, the date signaling the dawn of the atomic age, a group of physicists were requested to determine the health hazards presented by the new device and to protect the workers. Since these physicists were to be concerned with the health of radiation workers, they were called health physicists, according to Dr. K. Z. Morgan who was a member of that original group and is currently director of the Health Physics Division at ORNL. Since that time, this new interdisciplinary field acquired great importance; it became oriented toward the physical sciences in this country while in some parts of the world it developed into a medical specialty. The primary objective of the early workers was to establish basic standards and monitoring procedures for the protection of workers and people living in the neighborhood of atomic centers. The original group profited by the early experiences of the radium industry and succeeded to develop practices that are responsible for the excellent radiation safety record of the new atomic industry.

In addition to the prevention of radiation injury to workers, the new profession of health physics expanded its role into research, education and training. The training activities of the national laboratories relating to education in this interdisciplinary field originated as early as 1948 at Vanderbilt is an excellent example of successful collaboration with universities. Recipients of the AEC Health Physics Fellowship who are graduates of a technical field such as chemical, mechanical, or sanitary engineering, chemistry, physics, geology, etc. follow courses at a cooperating school, e.g., the University of Tennessee or Vanderbilt University. At these schools ORNL staff members participate in the classroom instruction, under contract with the University, followed by a three-month long on-the-job training in one of the eight participating laboratories which

which include the Argonne, Brookhaven and Oak Ridge National Laboratories, the Lawrence Radiation Laboratory, the National Reactor Testing Station, Pacific Northwest Laboratory, Puerto Rico Nuclear Center and the Savannah River Laboratory. They receive training in monitoring, dosimetry, instrument calibration, shielding, waste disposal, associated with reactors, high voltage machines, x-ray facilities, etc. and are given an opportunity to work on their master's or doctoral thesis. At present, eleven universities collaborate with the above-mentioned laboratories in the program.

Education is considered a very important function of the Health Physics Division of the Oak Ridge National Laboratory. Special courses have been arranged for medical officers of the Armed Forces lasting for 12 weeks; the division was responsible for the health-physics portion of the reactor school courses. Special series have been organized to train personnel whenever a major new project was started; thus, the Savannah River Plant and Idaho National Reactor Testing Station personnel, among others, receive intensive training at ORNL prior to their transfer to the new site.

In view of the great importance of safe radiation working practices for all laboratory employees, courses are given from time to time to all experimentalists who might encounter radiation problems during their work.

The foregoing represent two instances of collaboration between national laboratories and universities to train people with highly specialized qualifications, not available in the usual academic curriculum. As a result of these pioneering efforts, the new professions of nuclear engineering and health physics were generally accepted by the technical community.

The goals of scientific and technical education are furthered by other means at the national laboratories. A very close collaboration was envisioned by the director of our laboratory, Dr. Alvin M. Weinberg. In his paper "The Federal Laboratories and Science Education"* he

* Science, April 16, 1962, Vol. 136, No. 3510, pages 27-30.

points to the criticism levelled at the "big science" that it uses a large percent of the nation's technically trained manpower. The large government laboratories employ some 5% of all the science Ph.D.'s in the country but in the past they did very little teaching, deserving the less than complimentary epitaph of "scientific eunuchs", without intellectual offspring. Dr. Weinberg proposed four years ago to convert gradually this large Laboratory into a dual-scope research and educational institution, one of the chief goals of which would be education of Ph.D.s in the technical sciences. He pointed out that direct conversion of a research institute into a graduate school is not novel; Rockefeller Institute, now called the Rockefeller University has been chartered as a degree granting institution. He also remarked in the above-cited paper that it might be difficult to tell whether Massachusetts Institute of Technology is a university with many government institutions appended to it or a cluster of government research laboratories with a very good educational institution attached to it.

For various reasons, the original concept could not be carried out but the laboratories cooperate with educational institutions in many areas. The main aim was to make the technically trained manpower and specialized equipment available to an educational institution to take advantage of the specialized knowledge of the individuals. One of the most important programs in this field is the cooperation between the Oak Ridge National Laboratory and the University of Tennessee supported by the Ford Foundation. Similar cooperative efforts have been established between other national laboratories and their neighboring universities. According to this program a number of senior scientists in various fields have been named professors at the university; they spend as much as 20% of their time in on-campus teaching. Their basic salary is reduced by 20% but they receive a higher compensation from the university which in turn is reimbursed by the Ford Foundation for the expenses thus incurred. Contact with bright young students is a rewarding experience, in return the U.T. faculty was re-enforced by a number of highly competent research scientists. The teaching is not confined to graduate

level. As you so well know, preparation of a course is a good mental discipline; it forces the instructor to organize his thoughts carefully. To a lesser extent, similar teaching assignments at other institutions are also encouraged but because of the distances involved this usually means that a scientist or engineer in question leaves his job for a semester.

This program is also carried out in the opposite direction by providing summer employment for faculty members, designated as "research participants". This arrangement proved to be mutually advantageous: for the Laboratory during the years before large portions of nuclear energy fields became declassified, the presence of the summer research participants was like a breath of fresh air in a hothouse. Staff members attended mostly specialized, classified meetings and visited primarily other AEC laboratories. The faculty members brought us new points of view and became highly valued consultants, fellow workers and friends. At the same time they also profited from their stay at the Laboratory because it indicated desirable directions for research and instruction in the nuclear energy field. In many cases, work at the laboratory meant acquaintance with expensive research tools, not available in the smaller schools.

In addition to the summer work, faculty members (mostly from the southern universities) were extended invitations to spend one or two years at the Laboratory. This longer time period made it possible for the visiting professors to engage in more lengthy projects and to actually become members of research teams rather than a consultant.

Special programs have been organized also for the benefit of the students. The co-op student program is very well known to you; therefore I will not discuss here, beyond mentioning that the Laboratory is extremely satisfied with its operations. The student gains valuable experience and earns enough money to become practically self-supporting during his studies while the Laboratory gains the services of intelligent technicians. The presence of undergraduates in the Laboratory raised some disciplinary problems and it was found

necessary to emphasize safety aspects which are usually accepted more easily by more mature individuals.

Most national laboratories have a program of summer employment for students to replace technicians on vacation. The experience they gain during their stay is helpful in their studies. The participants usually have completed their sophomore or junior years; a good scholastic background is required to be chosen because the number of applicants exceeds greatly the number of available spaces. However, a certain number of places are reserved to students from schools without a graduate program, as a special "head start" type assistance.

This undergraduate program is supplemented with employment opportunities for persons working on their doctoral thesis or who want post-doctoral employment in research for a limited time. For the Oak Ridge National Laboratory and other southeastern facilities, such as the Savannah River Laboratory, this cooperation is carried out through the Oak Ridge Associated Universities which maintains contact with about 40 schools. The specialized facilities of the Laboratory are thus made available to these schools which will actually grant the degree. In addition, the Technical Information Division's technical editing, graphic arts and reproduction departments collaborate in the publication of the theses, relieving the students from additional financial obligations and making the results of the research more conveniently available.

Another important program of the Oak Ridge National Laboratory toward fulfilling engineering education goals is the establishment of an engineering practice school. This school has operated for about 15 years under the supervision of the Nuclear Engineering Department of M.I.T.; its headquarters was located at the Oak Ridge Gaseous Diffusion Plant but about three-fourths of the students were assigned to work at ORNL. Although the school was mainly attended by M.I.T. students, it was open to all universities; several University of Michigan students participated in this program at the very beginning. During the semester that the students spent at the Laboratory, they were assigned to operations or design projects and received training in areas of general interest, such as report writing, error analysis,

and statistics. They also had an opportunity to participate in the regular lectures and educational courses presented at ORNL, among which computer programming courses were especially popular. This engineering practice school has been terminated but discussions are in progress to reopen it again, placing it under the supervision of the Chemical Engineering Department of M.I.T. and reducing the actual period to about 10 weeks.

Students from the University of Tennessee's Nuclear Engineering Department participate in another special program: taking advantage of their physical closeness under the supervision of their own professors, they visit the Laboratory on a regular schedule, performing the experiments which were formerly part of the previously mentioned Oak Ridge School of Reactor Technology.

Another interesting cooperative program is carried out at the Argonne National Laboratory: students and faculty members move physically to that laboratory for a full quarter, participating in specialized courses, experiments and operations.

All these programs are aimed to assist university faculty members and students to broaden their background and to gain additional experience by participating in some manner in the Laboratory's activities. There is also another side of the coin: assistance is given to the Laboratory's personnel interested in educational activities. I would like to mention some of these programs which are indicative of the Laboratory's interest in furthering the goals of technical education. Direct financial support is provided to staff members to pursue their studies in order to obtain advanced degrees, take refresher courses, or simply broaden their professional competence They are reimbursed upon successful completion of the course. During the last year about 700 employees participated in this after-hours program which cost about $20,000 to the Laboratory.

The university study program extends the previous activity. It allows up to 8 hours per week of time-off during working hours, enabling the participants to attend regular university classes which are not offered in the extension courses; the time thus lost is made up during

the week or in the evening, at the convenience of the employee with the approval of his supervisor.

The Laboratory supervision makes every effort to assign to interested individuals research projects which are acceptable for thesis work, giving an opportunity to engineers and scientists to complete their thesis while earning a living. Often, Laboratory staff members act as thesis supervisors and examining committee members. Assistance is given also in reproduction and publication of the thesis as in the case of temporary employees.

In a few special cases, deserving employees may get a year of absence with full pay to complete their doctorate.

As you well know, a large amount of technical progress is made available at specialized symposia and scientific society meetings, such as this one. Staff members are encouraged to participate in such activities to help their professional growth. Similarly, every year a number of selected individuals are sent to short term courses organized by universities and professional societies. During the last year, 137 employees participated in this type of external specialized training courses at a total cost of $80,000, including the proportionate share of their salary, university fees, per diem and travel expenses.

In order to broaden the horizon of their employees, several divisions made special arrangements for exchanging personnel with other installations. A large percent of these exchanges involve relatively short visits but a program of residence exchange for periods up to one year has been in operation; this includes a number of foreign installations. Thus, employees of national laboratories exchange places with their colleagues in British, French, Australian, German, etc. research centers.

The above program is further extended by encouraging qualified people to apply for and to accept fellowships such as Fulbright or Guggenheim fellowships to pursue their studies. To avoid hardships in certain approved cases the Laboratory pays the difference between the fellowship and the individual's salary; their vested rights such as retirement, vacation and other benefit plans are fully protected.

In order to protect against technical obsolescence of the staff, special on-job refresher courses are organized by the various divisions in fields deemed of special importance by the director of that division. The Laboratory provides the participants with books and assigns them formally to these sessions held during working hours. Typical courses in the program include refresher lectures and review of the latest development in the fields. Among the typical recent offering were: chemistry, algebra, transistor fundamentals and use, calculus, air conditioning refresher course, field engineers electrical refresher course and principles of unit operations.

In doing this, the national laboratories follow current trends in engineering education. A recent article by Theodore N. Ferdinand* examines the various types of obsolescence encountered among technical men, concluding that the greatest degree of obsolescence is encountered in production-oriented industries where the technology does not change very rapidly. Thus, when an industry shifts from production to research and development, many of its engineers and scientists find themselves inadequate to fulfill their new type of assignments. Ability to handle new technologies can be found primarily in recent graduates of good engineering schools, and, according to the author, this is the reason why the newer electronics and aerospace firms have clustered around Boston and Pasadena. The national laboratories operate in a fast-moving field which should preclude obsolescence but even so, some may become over-specialized, overlooking developments in neighboring areas. The system of in-house education courses is aimed to prevent this.

The many technical seminars held daily at the Laboratory supplement the formal programs. Some of the seminars are scheduled regularly by the divisions on a given day of the week; others are organized on an ad-hoc basis to take advantage of the presence of well known visiting professors or other experts. As a result of this, there is a marked academic atmosphere around our Laboratory; our top management underlines the importance of the "scholarly approach" in the daily work. Subjects of general interest are covered in Laboratory-

* Obsolescence of Scientists and Engineers, American Scientist, Vol. 54, No. 1, 1966, pages 46-56.

wide "quarterly colloquia", corresponding to "distinguished speakers" of universities.

The close cooperation between universities and the national laboratory is also manifested in the frequent engagement of well-known educators, to be "in residence" at the Laboratory for a few weeks; during that time a weekly series of lectures on a specialized field are presented; the lecturer usually acts as a consultant during the rest of the time.

Another opportunity for professional growth is presented by appointment of senior staff members to specialized review committees. These committees cover a variety of areas, including various safety fields such as reactor operations, hot cells and sources, radiochemical plants, etc. The committees act as the eyes and the ears of the Laboratory director, reviewing the material presented to them by experimenters or operators of large facilities. Other committees cover review of design features of project proposals, long-range policy in various technical areas, etc. In most cases, there is a stimulating interplay between experts in neighboring fields.

Activities of the local section of the technical societies are formally outside of the scope of the Laboratory; however, the societies are supported by providing a framework for the operation of a Technical Societies Joint Council. The monthly subsidy enables the council to engage a full time secretary and to provide headquarters for the 16 technical societies which have now local chapters in Oak Ridge; half of them are engineering groups. As a result of this, the local technical man is able to select a talk of interest to him practically every evening, making up for the relative isolation of the site.

Up to now I discussed primarily the engineer and scientist; however, we should keep in mind the contribution of assistants. The Laboratory recognizes their importance and instituted strong programs to develop supporting engineering assistance. Among them is the technical qualification program which makes it possible for technicians working with engineering people to acquire a monthly employee status by taking the prescribed courses and passing an examination. This does not give him a formal technical degree but enables him to

break into the higher classification bracket. The program is strictly administered and the few people who passed the examination successfully enjoy the respect of their co-workers.

The technical qualification program encourages technicians to complete academic degree requirements or to acquire the appropriate knowledge by other means if formal education is not feasible because the applicant does not have the required educational background. The tests include fundamental examinations to measure basic technical knowledge, normally acquired in the first two years of college curriculum and a specialty examination to measure knowledge in a specialized field in which the participant is working. Later, a problem is assigned to measure the ability to apply acquired specialized knowledge and skills to an actual working situation. Finally, a general oral examination is given. Successful candidates are eligible for promotion to the appropriate professional classification.

Another area of formalized training effort is the apprentice training program under the supervision of the Federal Bureau of Apprenticeship. Currently about forty individuals are enrolled in this program working for three years before graduation; this work assignment includes four hours of classroom study per week.

Work in a multidisciplinary laboratory presents special advantages to engineers, not available under usual conditions. The presence of people with expert knowledge in areas remote from each other makes a special engineering symbiosis possible. In one of the most interesting projects, a biologist, who is an expert in viruses collaborated with engineers engaged in the design of ultracentrifuges, developing a novel method for separating viruses. Such special assignments may be considered as furthering the goals of engineering education.

In addition to these more or less formalized educational programs, I would like to describe briefly another area in which the national laboratory furthers the goals of engineering education by other means. I have a somewhat selfish reason for bringing up our activities in the field of information because this is my chief professional interest at the present time.

The ever-increasing flood of technical information which prevents the hardworking engineer and scientist to keep up with recent developments has been discussed repeatedly. Actually we encounter now an exponential growth of papers on handling of scientific information.

An information center is not a document depository; it is a group of working scientists who organize the literature published in their field of interest, storing the material in a suitable system from which it can be retrieved efficiently.* The output of the centers include bibliographic information, supplying documents, discussing a given combination of subjects, selection of best data on the basis of critical evaluation of available experimental results, publication of state-of-art reports, and use of other techniques which help to compress the literature. It is estimated that in some cases one page of the output of an information center obviates the need to read 50 pages of literature.

A large multipurpose laboratory, such as the national laboratories, is an excellent home for these information centers. Its variety of experts supply staffs for the centers which can mutually assist each other by providing coverage in neighboring fields.

Every effort is made at the Oak Ridge National Laboratory to make the centers a technical institute rather than a collection of documents. For this reason, management does not permit establishment of centers in areas in which the Laboratory does not have a strong technical competence. In view of the differences in the background of the technical men in the various fields of science and engineering, storage and retrieval are also quite varied; no attempt is made to force uniformity on them. Neutron physicists, accustomed to use computers, quite naturally developed a computerized system even though the volume of the literature was not too large because both the tools and the

* The concept of the information center was outlined and its activity strongly supported in a report of the Panel on Science Information of the President's Science Advisory Committee, entitled "Science, Government and Information" (the so-called Weinberg Report), The White House, January 10, 1963, pages 33-34.

know-how were available; less sophisticated systems were used in the other centers at the beginning. The other storage and retrieval methods used at ORNL include: the Termatrex (peekaboo) system; random-access, coded-microfilm unit (Miracode) and various manual indexing methods. Creation of a suitable thesaurus of keywords in each of the areas covered requires an extensive study.

The centers of special interest include the Nuclear Data Project, engaged in the systematic collection and evaluation of nuclear schemes, level properties such as energies, moments, and transition probabilities. The output of the center includes the Nuclear Data Sheets which as of this year is published in the new compilation journal "Nuclear Data". The Charged Particle Cross Section Data Center provides information on nuclear cross sections for charged-particle-induced reactions. The Isotopes Information Center's main scope is to reorganize the world's isotope literature on the basis of potential application or usefulness in particular industries. The Nuclear Safety Information Center by its very nature covers a wider territory, cutting across various disciplines. Its output is consulted by licensing and supervisory agencies. The Research Materials Information Center provides much needed information about the availability of high purity materials used in solid state research including both commercial and academic sources. The Radiation Shielding Information Center is also unique in one of its services: its computer code collection group evaluates tapes used in shielding computations making them available to interested parties after verification. The Information Center for Internal Exposure developed a mathematical model to reduce the large amount of fragmented data available in the literature to a common denominator which can be used for preparing internal and national standards in the field of intake of radioactive materials. The Atomic and Molecular Processes Information Center specializes in the field of electron heavy-particle heavy-particle and photon heavy-particle reactions and surface interactions of electric and magnetic fields with excited atoms or ions. The Criticality Information Center provides guidance to workers who must transport, handle or store fissionable materials outside of a reactor core. The Accelerator Information Center provides

an up-to-date listing of the physical features of accelerators throughout the world. The Space Materials Property Information Center (the only somewhat restricted agency) evaluates thermal, physical, mechanical and chemical properties of materials needed in aerospace nuclear safety studies. The Engineering Data Collection provides easy and convenient access to the several tens of thousands of engineering drawings by means of keypunched aperture cards; the microfilmed drawings in the collection can be enlarged to desired size by reader-printers available at strategic locations throughout the Laboratory. Information center activity is in progress on economic aspects and fabrication of reactor fuels and on some facets of the water desalination project.

Experience has shown that information centers are of special importance for persons working in the engineering fields. Pure scientists usually work fairly long time in a narrow field of their specialty and thus are usually personally acquainted with most of the laboratories in which work of interest to them is carried out. On the other hand, engineers are very often switched from one field to another. A design engineer does not necessarily have the inclination or the time to know all the theoretical problems involved in the corrosion studies of a certain alloy; he simply wants to be told what is the best material for use under a given set of circumstances. For this reason, I believe that the engineering profession will greatly profit from the proliferation of these information centers.

I hope that I have managed to give you a little review of the methods and means employed by national laboratories as examplified by the one that I know best, the Oak Ridge National Laboratory, to further the goals of science and technology, in cooperation with educational institutions.

Thank you very much for your interest.

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