OAK RIDGE NATIONAL LABORATORY

RESEARCH SUMMARY REPORT

FOR CALENDAR YEAR 1948

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Introduction

The following is a brief summary of the more important accomplishments in the various fields of research during the calendar year 1948 at the Oak Ridge National Laboratory. In accordance with instructions, this report does not include the results of the vast amount of research and engineering work relating directly to reactor development. The many problems investigated in this general field required a major part of the time and effort of the Technical Division, the entire efforts of the Power Pile Division, and appreciable assistance from other Divisions. It is understood that this part of the work will be covered in a report under preparation elsewhere.

During the year much progress has been achieved in carrying out the research and engineering development program having to do with basic and applied research. An effort has been made to place more emphasis on replacing temporary facilities with those of a more permanent type. The technical staff has been strengthened by the addition of several outstanding scientists. The change in responsibility for operating the Laboratory from the Monsanto Chemical Company to the Carbide & Carbon Chemicals Corporation on March 1, 1948, was effected with a minimum of interruption in the progress of the work. The general character of the Laboratory has become of a more permanent nature and the morale of the employees has been very satisfactory.

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Members of the Laboratory staff have taken an active and progressive part in local and national technical meetings and have contributed materially by presenting scientific papers covering the research and development work performed at the Oak Ridge National Laboratory.

During the latter part of March the Biology Division sponsored a general meeting in Biology and Medicine. Approximately 120 visitors attended, among whom were many of the country's outstanding specialists in fields of interest to the Atomic Energy Commission. Since most of the discussions were concerned with unclassified subjects, many prominent scientists were present who are not directly associated with any AEC installation.

A symposium on shielding problems was sponsored by members of the Technical Division during September. Discussions at this meeting were limited to classified subjects; therefore, attendance was restricted to those authorized to receive this type of information. Approximately 200 representatives from 42 sites were present.

On September 7th an interesting and informative meeting on low temperature phenomena was held in Oak Ridge, sponsored by the Physics Division. The discussions were conducted and guided by the most prominent scientists who have done extensive research in this field.

Laboratory Organization

The basic organization of the Laboratory is composed of seven research divisions whose activities are concerned with the general fields of Biology, Chemistry, Engineering Development, Health Physics, Metallurgy, Physics, and Power Pile Design. These are supported by

three other divisions whose primary functions are concerned with routine operations, engineering maintenance and construction, and industrial medicine.

The organization of the Laboratory staff may be briefly outlined as follows:

Executive Director	-	C. Nelson Rucker
Asst. Executive Director	-	S. C. Barnett
Assistants to the Director	-	F. P. Baranowski Edgar J. Murphy F. C. VonderLage

Division	Director
Biology	A. Hollaender
Chemistry	D. C. Bardwell
Health Physics	K. Z. Morgan
Metallurgy	J. H. Frye, Jr.
Operations	L. B. Emlet
Physics	A. M. Weinberg
Power Pile Design*	H. Etherington
Technical	M. D. Peterson.

The average number of scientific and technical employees at the Laboratory during the year was 700.

In addition to the permanent staff, the Laboratory has the assistance and guidance of approximately 75 prominent scientists engaged as Consultants who take an active part in determining the most logical method of pursuing specific problems. These are outstanding technical men recognized as experts in various fields of specialization. Among them may be mentioned:

*The Power Pile Division has been deactivated and most of its members have transferred to the Argonne National Laboratory.

Consultant	Institution
Weldon G. Brown	Univ. of Chicago
R. M. Boarts	Univ. of Tenn.
C. D. Coryell	Mass. Inst. of Tech.
Farrington Daniels	Univ. of Wisconsin
P. H. Emmett	Mellon Inst.
M. Goldhaber	Univ. of Ill.
Warren C. Johnson	Univ. of Chicago
K. Lark-Horovitz	Purdue Univ.
S. C. Lind	Retired, Univ. of Minn.
C. G. Niemann	Calif. Inst. of Tech.
L. W. Nordheim	Duke Univ.
F. Seitz	Carnegie Inst. of Tech.
E. D. Stiller	Squibb Inst.
J. A. Wheeler	Princeton Univ.
S. Wright	Univ. of Chicago
A. J. Vorwald	Trudeau Sanitarium
E. P. Wigner	Princeton Univ.

Biology

The work in Cytogenetics has progressed very satisfactorily. Some experiments were conducted in cooperation with Dr. Tobias of the Donner Laboratory involving the use of the 190 Mev deuteron beam from the large cyclotron. These were used to produce chromosomal rearrangement in tradescantia microspores. Preliminary results indicate there is a pronounced effect of ionization distribution due to the less energetic deuterons since they are most effective in producing dense ionization.

The construction of the biological thermal neutron chamber was completed. It has been calibrated and used for preliminary tests.

The relative efficiency of seven different wave lengths of ultraviolet light in producing a given effect on the nucleolus of the grasshopper neuroblast has been determined and studies of other wave lengths are in progress.

The investigation of micronuclear mutation induced by radiation has been mainly concerned with the inheritance of the mutation and the comparison of the effects of 250 KV X-rays with those previously obtained with beta rays from P^{32}. Preliminary experiments are now under way to determine if radiation of various kinds has any effect on this phenomenon.

A series of tests have been started to determine the modifications produced by ultraviolet radiation of bruchid eggs in three phases of early development. It is hoped that the results of these tests will yield information regarding the mechanism by which the modifications are produced.

The results of many determinations of the rate of photosynthesis and the function of dosage of ultraviolet radiation scenedesmus indicate that the ability to produce colonies on an agar-glucose nutrient medium mixture is considerably more sensitive to inactivation than are the photochemical processes.

In studying the effect of ionizing radiation on living rabbits it was found that the desoxyribonucleic acid production in the bone marrow is extremely sensitive to this radiation whereas the ribonucleic acid is less so. It was found in the irradiation of nucleo-

proteins in vitro that this material is very resistant to ionizing radiation whereas it is very sensitive to ultraviolet light. This is in contrast to the isolated sodium thymus nucleate which is very sensitive to both ionizing radiation and ultraviolet.

The work on the studies, separation, and purification of carrier-free beryllium has been completed.

Interesting results have been obtained regarding the use of the ion-exchange methods for the separation of nucleic acid components.

Extensive plans have been formulated for establishing a mouse genetics farm for studying the long-term effects of radiation on mammals.

Chemistry

During the past year the work performed by the Chemistry Division has been primarily concerned with basic research problems in the general fields of Organic, Inorganic, Physical, and Radiochemistry. In addition to the fundamental research, a great deal of time and effort have been devoted to Analytical Chemistry and the development of new methods for carrying out analyses of various materials.

The research and development work on the processes for recovering uranium from enriched reactors and U^{233} from irradiated thorium has been completed. This has made it possible to place more emphasis on the research having to do with the chemistry of heavy elements in solution. A study of the complexes of thorium in aqueous solutions was extended to fluoride systems employing extractions into a TTA-benzene phase for determination of stability constants of the complexes. The program covering the distribution of organic amines and

the effect of these amines as complexing agents for uranium and solvent extraction was completed.

The work on the xenon cross section problem progressed satisfactorily. The assembly of glass equipment for the large-scale preparation of I^{135} has been essentially completed. The mechanical loss of PdI_2 by hold-up on the plastic funnel has been virtually eliminated by applications of a silicon dioxide coating to the plastic surface. Gas counting apparatus has been calibrated by coincidence counting of Xe^{133} and Xe^{135}. Using this result, the calibration of the ion chamber for assay of I^{135} was checked with satisfactory results. In conjunction with this work, the decay scheme of I^{135} has been investigated. Although several new facts have been added it is still impossible to arrange these into satisfactory decay schemes.

Exploratory experiments on the separation of fission zirconium and columbium from separations process wastes by adsorption and ion-exchange showed charcoal to be promising for the isolation of these from the Redox raffinate. Considerable research and development work will be necessary to establish the optimum method.

Considerable work has continued on the chemical and physical modifications of ion-exchange procedures for the separation of rare earths, including studies of the eluting agents, properties of cation-exchangers, and application of "disjointed" columns.

The development of the chemical process for extracting C^{14} from irradiated beryllium nitride was satisfactorily completed.

Work on the experimental use of C^{14} was concentrated along three general phases; namely:

(1) The synthesis of low molecular weight intermediates containing C^{14}

(2) The study of reaction mechanisms

(3) The development of analytical procedures.

A dependable method was developed for the preparation of one-gram quantities of spectrochemically pure dysprosium, lutecium, ytterbium, and gadolinium.

Deuteron bombardment of enriched molybdenum isotope specimens made possible the identification of new technetium isotopes, characterization of their nuclear properties, and more definite mass assignments in many cases.

Investigation of the extraction of various metals into benzene solutions was extended to a study of lutecium, praseodymium, and element 61. In addition, evidence of the effectiveness of TTA extraction for separating hafnium from zirconium was obtained.

Initial experiments were conducted which were directed toward the characterization of Ba^{141} as part of the problem of studying the short-lived fission isotopes with half-lives from fractions of a minute to several minutes.

In the field of Radiation Chemistry the calorimetric measurements of the energy imparted to various materials while being subjected to radiations in the reactor were completed, and work was initiated to determine the rate at which hydrogen and oxygen combine at high temperatures when catalyzed by an aqueous slurry of U_3O_8.

Methods developed for the preparation of solutions of heavy element and rare earth compounds which are fluid at 77° K for adsorption spectral studies have yielded satisfactory results.

A sample of tritium gas diluted with normal hydrogen was analyzed for tritium with the gas density balance and condensed on palladium for use in the beta calorimeter. After calorimetric measurements of the tritium decay energy, the sample was converted to water and the heat evolution again measured. From these results and the rate of tritium evolution now being determined it will be possible to calculate accurate values for the half-life and average energy of decay.

The electron microscope and X-ray machine have been successfully used in studying the physical properties of several materials which may have many applications. For example, the fibrous fracture surface in extruded beryllium has been examined by electron diffraction, revealing the presence of foreign material. Although the identity of this material is still uncertain, it is known to be amorphous and shows no crystal growth at 800° C. Examination of high-fired beryllia samples by X-ray diffraction leads to the conclusion that no cubic zincblende structure is present but a phase of considerably lower symmetry in addition to the hexagonal phase. Of interest is the occurrence of this new phase only in samples from which graphite or beryllium carbide was not extruded and which were heated at, or above, 2000° C.

Reactor irradiation of magnesium, copper, and aluminum has been found to have no effect on the width of the X-ray diffraction line whereas rather strong effects were observed in samples of work-hardened copper-beryllium alloy. From these and other results for this alloy subjected to heat treatments it is tentatively concluded that irradiation produces more distortion on the crystal lattice of hard materials

than on soft ones.

The following analytical procedures were satisfactorily developed or are now under study:

(1) Spectrophotometric determination of aluminum in the presence of iron

(2) The use of ammonium thioglycolate as a colorimetric reagent for uranium

(3) Colorimetric determination of selenium with pyrolle

(4) Determination of uranium in the presence of potassium dichromate by the thiocyanate method

(5) Colorimetric determination of tellurium with thiourea

(6) Colorimetric method for the determination of zirconium

(7) Radiochemical method for plutonium.

The spectrographic determination of the amount of hafnium in zirconium has been further refined, now permitting analyses over the range 0.065 - 8.0%.

During the past year the number of chemical analyses made for the various technical groups amounted to an average of about 11,000 per month.

Metallurgy

Construction of the metallurgical laboratory and the installation of the major items of equipment have been completed. This laboratory is equipped with excellent facilities for the melting and casting, mechanical working and heat treating, physical and mechanical testing, and metallographic examination of metals and alloys of wide interest. Adequate health hazard safeguards have been designed and are now being installed. Upon completion of this installation an extensive program

of fundamental and applied research on uranium, beryllium, and zirconium and their alloys will be instigated.

Preliminary studies have been made on the effect of thermal stresses on the dimensional instability of uranium. In connection with these studies, special apparatus for inducing thermal stresses in slugs similar to those experienced in the Hanford reactor have been designed and constructed and preliminary tests started.

The investigation of the effect of radiation on metallurgical reactions is well underway. With the expanded facilities this study will proceed at a greatly increased rate.

Physics

Considerable work has been done in studying the physics of solids as related to the changes in physical properties produced when subjected to intense radiation. Some of the studies were designed to investigate the cause of the blistering of slugs in the Hanford operating units. This phase of the work is still under investigation.

By comparing similar samples with different Al-U ratios it was possible to ascertain that the fraction of atoms fissioned determines the magnitude of the change in the thermal conductivity independent of original Al-U ratios. Results indicate that the electrical conductivity changes; on the other hand, it seemed to depend on the state of agglomeration of uranium in the alloy. It appears that a homogeneous mixture of uranium is more susceptible to damage than a mixture in which uranium is segregated in small particles.

Crystal disorder has been produced in the orderly arrangement of Cu-Au alloy by neutron bombardment. Similar changes in resistance have been found in Cu-Be alloy. Marked hardness increases following neutron bombardment were found in stainless steel, monel, and kovar.

The release of radioactive gas from irradiated Al-U alloys at temperatures between 200° C and 500° C has been measured. On the basis of data determined thus far it appears that Kr^{85} is released at a maximum rate at a temperature of 250° C.

An effective method of calculating the critical mass in the system with finite reflector has been developed. The scheme which is applicable if core and reflector have similar slowing down properties involves an application of the fundamental theorem of pile theory and expansion of characteristic functions.

Various processes involving purely electromagnetic interaction between a liquid drop nucleus and a charged particle have been studied. Among these are meson-induced fission, electron-induced fission, and capture of a negative meson with emission of gamma radiation.

A new method of solving time dependent quantum mechanical problems has been developed. The technique involves an expansion of the time dependent wave function as a Fourier transform in solutions of the corresponding time independent problem.

Significant results have been obtained in the development of solid scintillation counters. It was discovered that anthracene and napthalene will count fast neutrons and alpha particles. The effect of temperature on pulse sizes produced with this type of counter has been studied. The results show that napthalene pro-

duces a greater pulse height increase than anthracene as the temperature is lowered, which is in accordance with expectations. Alkali halide and anthracene counters have been compared. Larger pulses are produced by the alkali halides than by the anthracene; however, the duration of the light flashes and, therefore, the resolving time, is longer. Extensive studies of the mechanism of Geiger counter discharge indicate that electron collection plays an important role in the discharge when the counter voltage is well above the threshold value.

A change in the scattering of polarized X-rays from a scatterer caused by an AC magnetic field has been investigated using gamma rays from Au^{197}. Although the experiments are not entirely consistent, there seems to be some evidence that an AC field does increase the scattering of polarized gamma rays from a scatterer.

Considerable work has been devoted to theoretical studies having to do with the problem of lining up nuclear spins in low temperatures at high magnetic fields.

Coincidences between decay beta particles and protons have been observed in neutron decay experiments. The coincidence rate is lower than would be expected from the single counting rate.

A specially prepared highly purified specimen of zirconium (almost hafnium free) was found to have a slow neutron capture cross section of approximately 0.4 barns, of which 0.15 barns is attributable to the residual boron impurity. In view of this result and the fact that zirconium has very good physical and structural properties it appears very attractive as an almost ideal

material for constructing essential reactor components. For equal strength it has a cross section only about one-fifth as large as that of aluminum.

The first successful Laue pattern of neutron diffraction from crystals has been obtained. The blackening of the photographic plate was achieved by backing up the plate with indium which emits beta particles following the neutron capture. This technique has proved quite useful in studying other problems.

Transmission measurements with the neutron crystal diffraction apparatus have been made on cobalt and hafnium. There are strong resonances in hafnium at positions where zirconium is alleged to have weak resonances. It is practically certain that the original zirconium resonances were due to hafnium impurities.

An absorption resonance of 0.5 eV, of at least 1700 barns, has been found in very pure Er_2O_3. Results of measurements made on coherent scattering cross section of Ni^{58} indicate a value of 26 barns. This is in agreement with the value obtained from powder diffraction studies.

The general problem concerning capture gamma ray work has been conducted along three lines; namely:

(1) Measurement of capture gamma rays from Cl by production of pairs in a cloud chamber with Pb radiator

(2) Study of capture gamma rays with a crystal counter

(3) Photographic plate studies with D_2O impregnated plates.

A series of criticality experiments have been completed. In the course of the work studies were carried out using as reflectors water, P-9, lead, aluminum, beryllium, and graphite. The adequacy

of cadmium and thorium safety rods also has been demonstrated, and the heat generated by the gamma rays in the proposed experimental holes has been measured.

Training Activities

The Practice Training Program for visiting trainees and the Resident Graduate Program for employees in cooperation with the Oak Ridge Institute of Nuclear Studies (ORINS) and the University of Tennessee were continued during the year. Policies for participation of employees in the latter were established and procedures to allow credit for advanced degrees were formulated.

Several new programs were instituted, including the Graduate Training Program and the Professional Health Physics Training Program. The Laboratory assisted ORINS in the conduct of its Radioisotopes Techniques School by loaning prrsonnel and equipment for instruction purposes. The Training School Division was discontinued in April and similar activities were conducted by the separate Divisions and coordinated through the Executive Director's office as a staff function.

The Resident Graduate Program provides graduate university training for employees who were, in some cases, working toward an advanced degree. Classroom work was provided by the University of Tennessee at Oak Ridge with opportunities to apply laboratory research work at Oak Ridge National Laboratory toward thesis requirements. Approximately 50 employees attended these classes during the winter and spring quarters with 70 enrolled in the fall quarter. Five employees are now engaged in thesis research at the Laboratory.

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A course, The Introduction to Nuclear and Pile Physics, was conducted at the Laboratory with an enrollment of approximately 90 employees. This was a class conducted to furnish fundamental scientific information to be applied to on-the-job training for technical personnel.

The Graduate Training Program established in April provided for graduate students enrolled in universities to be nominated by the ORINS for employment at the Laboratory. Conditions of employment allow assignment of work to permit simultaneous completion of thesis requirements for the Ph.D. in cooperation with representatives of the applicant's university. Three nominations were submitted by ORINS during 1948. One was accepted and two are pending acceptance of an employment offer.

The Professional Health Physics Program was started during the year. Arrangements were formally made in October and beginning on November 1st ten AEC fellowship recipients began a year's training, including basic physics and professional health physics classroom work combined with extensive instrument and practice field training. The need for such experience is very great and it is hoped it can be expanded in the near future.

During the year the Practice Training Program was continued. This program is general in nature and designed to serve miscellaneous and urgent requests from various agencies including the AEC, Army, Navy, Chemical Warfare Service, Public Health Service, universities, and industry. The trainees came at irregular intervals for unspecified periods of training. The total number in this category is

approximately 75, of whom about 25 were assigned for training in the Health Physics Division for periods ranging from two weeks to a year.

Instrumentation

A great deal of effort has been expended toward the improvement of the existing radiation instruments for use in routine monitoring and general research work. Included in this part of the general program were the following major activities:

(1) A critical study of existing radiation instruments and instrumentation needs

(2) Electrical and mechanical development of proposed instruments

(3) Production design engineering and specification writing

(4) Design, developing, and testing instruments for the high flux reactor.

Specifications have been written and contractual negotiations arranged for the development and production of a number of oscilloscopes especially adapted to photographic as well as visual observation of random pulses with extremely short rise time.

Circuit specifications and better operations have been incorporated in the sweep type differential alpha energy analyzer. Several coincidence circuits have been investigated in the process of developing circuits with resolution times of 10^{-7} seconds or less. A simplified circuit has been developed for use with the flow type proportional chamber, permitting counting of weak beta emitters as well as alpha emitters.

A special electronic instrument has been designed and developed to measure the pile period at levels far below the operating power up to full power. It provides signals which can be used to actuate shim and safety rods in such a manner that dangerously short periods are never reached. It has been used successfully for several months in connection with the operation of the X-10 reactor.

An anti-overload amplifier which permits a very wide pulse height distribution in associated particle detecting equipment has been developed. Also, diode tube characteristics have been studied in an attempt to increase the sensitivity of certain low intensity radiation detection instruments.

It has been demonstrated that many radiation detection instruments can be simplified and their usefulness extended by making use of the approximately logarithmic relationship between the grid current and plate currents of electrometer tubes.

The instrumentation problem and the one that required the most time, effort, and technical ability was the design and development of instruments for the operation of a high flux reactor. The following electronic circuits were designed and given preliminary tests:

(1) Shim rod control

(2) Safety circuit

(3) Counting rate meter

(4) Period meter

(5) Ionization chamber

(6) Electrically operated servo system.

Research Facilities

There have been a number of significant additions to the research facilities and many improvements to existing ones during the year. Laboratories of a more permanent nature have been constructed and equipped for three Divisions; namely:

(1) Biology

(2) Health Physics

(3) Metallurgy.

The Biology Division took advantage of the opportunity to renovate and occupy a large permanent type building in the Y-12 area. The major part of the building alteration and installation of equipment has been completed.

Laboratories of a semi-permanent type for the Health Physics and Metallurgy Divisions were constructed at the X-10 plant. Most of the essential equipment for these laboratories has been installed and in use for several months.

Many items of essential research equipment such as the 700-ton extrusion press, forge hammer, rolling mill, swaging machine, X-ray tube, polarimeter ultra-centrifuge, ultraviolet microscope, and electrophoroses machine were acquired during the year.

Other major facilities which were completed or which are under construction are:

(1) Thermal gradient equipment for heat treating slugs

(2) Off-gas filtration equipment

(3) Solvent extraction experimental facilities

(4) Pile mock-up installation

(5) Radioisotope development and production laboratory

(6) Chemical waste evaporator.

Publications

The staff of the Laboratory has presented for publication in scientific and technical journals about 85 papers describing various phases of the research work accomplished during the year.

In the field of physics a total of 24 papers have been declassified and published in the open literature. Five of these were concerned with studies on the diffraction of neutrons; four were theoretical papers on nuclear physics; three on instrumentation; and the remainder covered work on various other phases of nuclear physics.

Twelve papers on various biological investigations were published in appropraite journals. These were chiefly concerned with the effects of different types of radiation on living organisms.

Eight articles pertaining to industrial medicine have been published in various medical and nursing journals, and 14 having to do with health physics appeared in several scientific magazines.

The results of most of the declassifiable research work in chemistry have been submitted to the leading chemical journals for publication. During the year a total of 30 articles was submitted and about an equal number were presented at scientific meetings.

In addition to the above-mentioned publications, approximately 180 classified reports have been prepared and distributed to AEC installations in accordance with the standard distribution list for technical reports.

Edgar J. Murphy/ebr

November 12, 1948