

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES



3 4456 0251721 1

ORNL-1420

Progress

5a

HEALTH PHYSICS DIVISION

QUARTERLY PROGRESS REPORT

FOR PERIOD ENDING OCTOBER 20, 1952



CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION

LIBRARY LOAN COPY

DO NOT TRANSFER TO ANOTHER PERSON

If you wish someone else to see this document,
send in name with document and the library will
arrange a loan.

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION



POST OFFICE BOX P
OAK RIDGE, TENNESSEE

ORNL-1420

This document consists of 14 pages.
Copy 5 of 320 copies. Series A.

Contract No. W-7405-eng-26

HEALTH PHYSICS DIVISION
QUARTERLY PROGRESS REPORT
For Period Ending October 20, 1952

K. Z. Morgan, Director

DATE ISSUED

DEC 11 1952

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES



3 4456 0251721 1

OAK RIDGE NATIONAL LABORATORY
Operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

INTERNAL DISTRIBUTION

- | | |
|--|----------------------------|
| 1. G. T. Felbeck (C&CCC) | 37. D. W. Cardwell |
| 2. Biology Library | 38. E. M. King |
| 3. Health Physics Library | 39. M. T. Kelley |
| 4. Metallurgy Library | 40. E. E. Anderson |
| 5-6. Central Research Library | 41. R. S. Livingston |
| 7. Reactor Experimental
Engineering Library | 42. C. P. Keim |
| 8-16. Central Files | 43. G. H. Clewett |
| 17. C. E. Center | 44. C. D. Susano |
| 18. C. E. Larson | 45. L. B. Farabee |
| 19. W. B. Humes (K-25) | 46. F. J. Davis |
| 20. L. B. Emler (Y-12) | 47. R. J. Morton |
| 21. A. M. Weinberg | 48. C. E. Haynes |
| 22. J. A. Swartout | 49. Hugh F. Henry (K-25) |
| 23. E. D. Shipley | 50. E. G. Struxness (Y-12) |
| 24. E. J. Murphy | 51. W. E. Cohn |
| 25. F. C. VonderLage | 52. H. H. Hubbell |
| 26. K. Z. Morgan | 53. H. K. Richards |
| 27. S. C. Lind | 54. J. Neufeld |
| 28. A. S. Householder | 55. D. D. Cowen |
| 29. C. S. Harrill | 56. P. M. Reyling |
| 30. C. E. Winters | 57. M. J. Skinner |
| 31. A. H. Snell | 58. J. C. Hart |
| 32. E. H. Taylor | 59. T. H. J. Burnett |
| 33. R. C. Briant | 60. W. J. Lacy |
| 34. J. S. Felton | 61. L. A. Krumholz |
| 35. A. Hollaender | 62. G. S. Hurst |
| 36. F. L. Steahly | 63. T. E. Bortner |
| | 64. R. F. Bacher |

EXTERNAL DISTRIBUTION

- 65. Massachusetts Institute of Technology (Department of Electrical Engineering)
- 66. University of California (Gerhard Klein)
- 67-68. Ohio State University (Professor of Naval Science)
- 69. R. M. Richardson, U. S. Geological Survey,
2-C P. O. Building, Knoxville, Tennessee
- 70. C. V. Theis, U. S. Geological Survey,
Box 433, Albuquerque, New Mexico
- 71-320. Given distribution as shown in TID 4500 under Health and Biology Category.

CONTENTS

	Page
RADIOACTIVE-WASTE DISPOSAL RESEARCH	1
Water and Liquid-Waste Decontamination Processes	1
Surveys and Evaluations – Field and Laboratory	1
ECOLOGICAL STUDY	4
THEORETICAL PHYSICS	5
Fast-Neutron Tolerance Calculations	5
Thermal-Neutron Tolerance Calculations	5
Stopping Power of Fission Fragments in Light Gases	5
Energy Distribution of Multiple-scattered Electrons in Foils	5
RADIATION DOSE	6
Internal Radiation Dose	6
Radiochemical analysis	6
Spectrographic analysis of human tissue	6
External Radiation Dose	6
Backscattering of beta particles	6
Measurement of ionizing radiation by high-frequency variation	6
X-ray dosimetry	6
Tissue depth dose for fast neutrons	7
Shielding	7
Film monitoring for fast neutrons	7
Energy losses of electrons in foils	7
PHYSICS OF NUCLEAR RADIATION	7
Ionization by Alpha Particles	7
Measurement of the Electron-Attachment Coefficient for Various Gases	8
Dosimetry for Animal Exposures	8
EDUCATION, TRAINING, AND CONSULTATION	9
AEC Fellowship Program	9
Training Program for AEC Contractors' Personnel	9
Consultation	9
EXPERIMENTAL RADIATION MEASUREMENTS	9
Uranium Prospecting	9
AIRBORNE RADIOPARTICULATE CONTAMINATION	10
Radioactive-Particle Program and PEEP	10
PUBLICATIONS	10

Reports previously issued in this series are as follows:

ORNL-166	Period Ending August 31, 1948
ORNL-227	Period Ending November 30, 1948
ORNL-346	Period Ending February 28, 1949
ORNL-375	Period Ending July 15, 1949
ORNL-495	Period Ending October 15, 1949
ORNL-596	Period Ending January 15, 1950
ORNL-695	Period Ending April 15, 1950
ORNL-786	Period Ending July 15, 1950
ORNL-877	Period Ending October 20, 1950
ORNL-968	Period Ending January 20, 1951
ORNL-1086	Period Ending July 20, 1951
ORNL-1174	Period Ending October 20, 1951
ORNL-1277	Period Ending January 20, 1952
ORNL-1353	Period January 20 to July 20, 1952

HEALTH PHYSICS DIVISION QUARTERLY PROGRESS REPORT

RADIOACTIVE-WASTE DISPOSAL RESEARCH

R. J. Morton

WATER AND LIQUID-WASTE DECONTAMINATION PROCESSES

M. W. Carter	W. J. Lacy
F. L. Cobler	D. A. Pecsok
R. H. Dean	O. R. Placak
C. E. Graham	M. S. Seal
H. L. Krieger	C. P. Straub

Experimental Study of Commercial Water-Purification Devices. Two types of commercial water-purification units were evaluated with respect to their effectiveness in removing the radioactive components from a solution of fission products. Twelve units were tested of which four units were provided gratis by the manufacturer and eight units were purchased by the Laboratory. All units contained 36 g of a mixture of diatomaceous earth and activated carbon, 22 g of Nalcite SAR resin, and 22 g of Nalcite HCR resin; and 9 of the 12 units contained, in addition, 42 g of powdered iron. The solution used had an activity of approximately 10,000 c/m/ml (at 10% geometry) and was of the following approximate composition: strontium-yttrium 27.6%, cerium-praseodymium 17.4%, ruthenium-rhodium 3.9%, promethium 22.1%, samarium 1.4%, cesium 27.2%, and other radioisotopes 0.4%. Six series were run and the results are summarized in Table 1. It will be noted that the percentages of removal were quite variable even under similar test conditions. When tap water was used as the diluent, the highest removal observed was 98%. With distilled water, initial removals of 99% were obtained.

SURVEYS AND EVALUATIONS - FIELD AND LABORATORY

T. W. Brockett	F. Kalil
M. J. Cook	R. J. Morton
J. M. Garner	R. L. Nichols
B. Kahn	O. R. Placak
H. J. Wyrick	

Ground-Water Conditions at Waste-Storage Pit No. 2. Studies of ground water and other conditions in the vicinity of pit No. 2 have been

continued as outlined in a previous report.⁽¹⁾ With cooperation and assistance from the U. S. Geological Survey, the two test wells nearest the pit have been equipped with continuously recording water-level gages and the water level in a third well has been measured periodically. Three water samples from each of the three wells have been collected for chemical analysis and radioassay. Frequent radiologging measurements in the wells have been made before and after radioactive wastes were transferred to the pit.

Relatively small quantities of liquid radioactive wastes (a total of 16,200 gal) were transferred and deposited in the pit on June 20 and 27 and during the period September 12 to 19, 1952. Until about August 1 all three wells were uncontaminated. On August 12 radiologging indicated a considerable amount of radioactive contamination in one test well and a small amount in another. These two wells are on opposite sides of the pit and approximately 80 ft from the waste pool at the bottom of the pit. The third well, which is 200 ft from one end of the waste pool, was still uncontaminated on October 1. Radiochemical analyses of two samples of water from the more heavily contaminated well indicated that the radioactive material reaching this well from the pit was entirely Ru¹⁰⁶. The water table underneath the pit is approximately 6 ft lower than the bottom of the pit and has fluctuated less than 2 ft during the entire period of observation.

The data obtained thus far from the ground-water studies indicate that the shale formation is quite uniform and impermeable, a high degree of adsorption of the radioisotopes contained in the wastes occurs (with the exception of ruthenium), and the ground-water level is relatively stable with small, lateral flow rates.

The more rapid and far-reaching migration of ruthenium through the shale formation is of particular interest considering the eight valence states and the various chemical forms in which

(1) T. W. Brockett et al., *H-P Prog. Rep. Jan. 20, 1952 to July 20, 1952*, ORNL-1353, p. 4.

TABLE 1. SUMMARY OF RESULTS

SERIES	INFLUENT ACTIVITY (c/m/ml)	REMOVAL FOR VARIOUS VOLUMES OF THROUGHPUT (%)				AVERAGE REMOVAL IN FIRST 40 LITERS OF THROUGHPUT (%)	FLOW RATE*	pH OF INFLUENT	pH RANGE OF EFFLUENT	PRESENCE OF VISIBLE IRON FLOC	REMARKS
		20 liters	40 liters	60 liters	80 liters						
A	10,970	38	39	39	54	40	0.28 liter/min	7.8	8.9 to 10.0	None	Distilled water flushed through unit for first 20 liters at 3.78 liters/min
B	12,260	95	92	77	60	94.8	20 liters at 3.78 liters/min 2 liters at 0.014 liter/min 54 liters at 0.43 liter/min	7.7	7.3 to 7.7	Much	Spiked solution flushed through units for initial 5-min period at 3.78 liters/min
C-1	11,540	98	95	90	84	98.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.8 to 7.6	Much	Spiked solution flushed through units for initial 5-min period at 3.78 liters/min
C-2	9,100	94	88	82		93.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	7.0 to 7.6	Much	Spiked solution flushed through units for initial 5-min period at 3.78 liters/min
C-3	9,100	87	76			85.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.5 to 7.1	Much	Spiked solution flushed through units for initial 5-min period at 3.78 liters/min
D-1	9,100	75	51			66.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.0 to 7.2	None	Unit does not contain powdered iron
D-2	9,100	84	49			76.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.0 to 7.2	None	Unit does not contain powdered iron
D-3	5,380	84	48	43		75.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.2 to 7.1	None	Unit does not contain powdered iron
E-1	10,380	54	42			58.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	10.0	8.2 to 9.4	Little	Influent pretreated by alum coagulation and sand filtration
E-2	10,380	62	47			64.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	10.0	7.6 to 8.6	Little	Influent pretreated by alum coagulation and sand filtration
E-3	10,380	54	38			56.0	20 liters at 3.78 liters/min Balance at 0.47 liter/min	7.4	6.2 to 7.4	Little	Influent pretreated by alum coagulation and sand filtration
F	1,790	99	99	99	43	98.8	20 liters at 3.78 liters/min Balance at 0.47 liter/min	4.4	4.9 to 6.0	Dissolved iron present	Radioactive material diluted with distilled water

*Manufacturer's operating instructions are in terms of gallons and of pints per minute: 3.785 liters/min = 1 gal/min; 0.473 liter/min = 1 pt/min.

this element may occur. This emphasizes the importance of information concerning the variations in behavior of the different chemical forms of the same element. In some situations the environmental hazards from liquid wastes may depend largely upon the chemical forms in which the radioactive materials are present. For example, the data in Table 2 (next section) show that Ru^{106} , which was in the form of ruthenium chloride, was almost completely removed in experiments using shale taken from the site of pit No. 2. In contrast, analyses from the test wells showed that ruthenium passed through more than 80 ft of the shale formation. It is probable, although not confirmed, that this contaminant was present in the wastes as a ruthenate or in other forms that do not interact with the shale material in the same manner as does ruthenium chloride.

Adsorption of Radioisotopes by Natural Soils. The study, initiated about six months ago, of the adsorption of radioisotopes from liquid wastes by natural soil materials is being continued. The purpose is to obtain more specific information than is now available regarding the removal and fixation of certain isotopes and mixtures of isotopes by the soil whenever radioactive materials

are released or deposited, for example, in burial grounds, lagoons for sludge or liquid wastes, or from a more widespread dispersion of radioactive contaminants resulting from emergency conditions. Such information is of general interest wherever radioactive contamination of surface or underground soils may occur and is of particular interest to the Laboratory in relation to liquid-waste disposal.

Shale samples obtained from the site of waste storage pit No. 2 have been used in a series of tests to determine the adsorption capacities of the shale for certain radioactive isotopes and mixtures of isotopes. Two methods of testing were used, namely, jar tests and columns.

In the case of the jar-test studies, a range of pulverized shale samples (0.5 to 20.0 g) was placed in a series of one-liter beakers, each beaker containing 500 ml of tap water contaminated with the radioactive isotope or mixture of isotopes to be tested. The contents of the beakers were mixed rapidly (216 rpm) for various intervals (30 min, 1 hr, 2 hr), allowed to settle, and then were sampled for counting. The results obtained are shown in Table 2.

TABLE 2. REMOVAL OF RADIOACTIVE ISOTOPES BY SHALE^(a)

(Jar-Stirring Method)

JAR NO.	SHALE (g)	OVER-ALL REMOVAL AFTER STIRRING FOR 2 hr (%)									
		Ba ¹⁴⁰	Ce ¹⁴⁴	Cs ¹³⁷	I ¹³¹	P ³²	Ru ¹⁰⁶	Sr ⁹⁰	Zr ⁹⁵	MFP ^(b)	W-8 ^(c)
1	0.5	91.8	98.0	98.2	8.6	48.6	93.0	39.8	98.4	83.5	71.6 ^(c)
2	1.0	94.7	98.3	98.6	22.2	75.2	97.8	40.7	99.0	87.7	74.6
3	2.0	96.4	97.2	98.4	21.8	87.1	98.3	45.1	99.0	90.3	73.4
4	3.0	97.5	99.7	99.2	24.0	82.4	99.5	54.4	99.1		79.5
5	5.0	98.2	98.9	99.2	35.7	88.3	99.5	64.1	99.3	94.7	81.0
6	10.0	99.3	99.9	99.2	39.5	88.2	99.5	73.6	99.4	96.6	83.9
7	12.0	99.5	99.9	99.2	49.2	98.2	99.6	71.9	99.3		81.4
8	15.0	99.7	99.9	99.5	56.8	95.8	99.5	76.9	99.2		84.0
9	18.0	99.8	100.0	99.5	56.1	99.3	99.7	78.0	99.7		82.4
10	20.0	99.8	100.0	99.7	66.9	99.2	99.8	76.8	99.6	98.2	85.2

(a) Level of activity used averaged 3.24×10^{-2} $\mu\text{c}/\text{ml}$ or 7200 c/m/ml.

(b) Three-year-old mixed fission-product solution containing approximately 16% Cs, 20% trivalent rare earths, 2% Ru, 20% Sr, 21% Ce, and 21% unknown.

(c) Waste from W-8 waste-storage tank.

HEALTH PHYSICS DIVISION QUARTERLY PROGRESS REPORT

For the column studies, a series of lusteroid columns, $1\frac{1}{4}$ in. in diameter and 6 in. long, were set up and 75 g of shale sieved to 60 to 70 mesh was placed in each column. Two thousand milliliters of tap water containing the radioactive isotope to be studied was allowed to flow by gravity through each column at a rate of about 20 ml/hour. The effluent was sampled after approximately every 100 ml of flow. Under these conditions 100% removal was obtained for the following isotopes: Ba¹⁴⁰-La¹⁴⁰, Ce¹⁴⁴-Pr¹⁴⁴, Cs¹³⁷, P³², Ru¹⁰⁶-Rh¹⁰⁶, and Zr⁹⁵-Nb⁹⁵. However, a maximum removal of 87.3% (at 100 ml of flow) and a minimum of 65.3% (at 1900 ml of flow)

were obtained for I¹³¹. For Sr⁹⁰-Y⁹⁰ a maximum removal of 98.2% (at 100 ml of flow) and a minimum of 79.6% (at 2000 ml of flow) were obtained. A maximum removal of 99.9% (at 100 ml of flow) and a minimum removal of 93.2% (at 2000 ml of flow) were obtained for the fission-product mixture (same as used in jar tests). A maximum of 98.5% (at 50 ml of flow) and a minimum of 85.7% (at 1800 ml of flow) were removed from the waste from tank W-8. The level of activity used in the column tests averaged approximately 3×10^{-2} $\mu\text{c/ml}$.

A mathematical correlation of the results from the two methods has not been possible because of insufficient data. The work is being continued.

ECOLOGICAL STUDY⁽¹⁾

L. A. Krumholz W. T. Helm
E. R. Eastwood W. T. Miller
 W. A. Mills

Work on the fifth semiannual estimate of the fish population of White Oak Lake was begun on September 22 and will continue for approximately five weeks. The report for the fourth such study was distributed on July 29.

Research has continued on the accumulation of radioactive materials in different tissues of various fish, amphibious reptiles, and birds from White Oak Lake, along with similar studies on plankton organisms and bottom fauna.

A year-round study on the accumulation of long-lived fission products in bluegills and black crappies from White Oak Lake, begun in the summer of 1951, indicates that there is a definite seasonal variation in the amount of such materials accumulated in the different tissues. Although different tissues have an affinity for different chemical elements, the pattern of seasonal variation appears to be the same for all tissues. All tissues accumulated a minimum of radioactive materials during the winter months (December to

March, inclusive). In the spring, as the water temperature rose, the metabolic rate of the fish increased and was accompanied by an increase in accumulation of radioisotopes. Although the warm months of the year extended from May through September, the accumulation of fission products in the fish tissues continued to rise until late July, and then began to diminish. By mid-October 1952, the amount of radioactive materials in the various tissues was approximately the same as it had been at that time the previous year. Apparently the accumulation of radioactive materials in the various fish tissues depends primarily on three factors: (1) the temperature of the water, which largely controls the metabolic rate of the fish living therein, (2) the presence of an ample food supply containing the radioactive materials, and (3) the availability of that food supply to sight-feeding fishes, as controlled by the turbidity of the water.

The field work in the botany section of the biological survey has been terminated and the preparation of the final report is now in progress.

⁽¹⁾In cooperation with the Tennessee Valley Authority.

THEORETICAL PHYSICS

J. Neufeld W. S. Snyder
R. H. Ritchie

FAST-NEUTRON TOLERANCE CALCULATIONS

A program for the calculation of the energy dissipation of fast neutrons in tissue is being prepared for the UNIVAC and the ORACLE. The Monte Carlo method will be employed, using point sources of isotropically distributed neutrons. The anisotropy of the scattering is being studied, using recent results of NDA, and it is hoped to take it into account in future programs. For the present, the source energies to be used will be between 5 kev and 1 Mev, where most of the rise in the dosage curve occurs.

The correlation of the experimental data of G. S. Hurst and T. A. Barr with the previous Monte Carlo study at 2.5 Mev seems excellent, although the present data are scanty.

THERMAL-NEUTRON TOLERANCE CALCULATIONS

A program has been prepared for use on the NEPA machine to calculate a variety of thermal-neutron dosage curves for slab and sphere geometries. The scattering is assumed to be isotropic in the laboratory coordinates and the neutrons are considered to be monoenergetic. The bodies of interest will be of intermediate size, ranging from 1 to 10 cm in radius or thickness, so they will approximate the conditions of many animal experiments.

STOPPING POWER OF FISSION FRAGMENTS IN LIGHT GASES

The energy loss resulting from atomic collisions has been calculated by Bohr⁽¹⁾ on the basis of statistical models both for the moving atom and

⁽¹⁾N. Bohr, *Phys. Rev.* 59, 270 (1941).

the stopping atom. The statistical model is not very applicable to light gases; therefore modified calculations will be made to estimate the stopping power of heavy ions in light gases.

ENERGY DISTRIBUTION OF MULTIPLE-SCATTERED ELECTRONS IN FOILS

Landau⁽²⁾ has studied the effect of straggling on the energy distribution of electrons in thin foils. Angular deflections, which are mainly due to elastic scattering, give rise to greater energy losses and more energy straggling than predicted by Landau's theory.

To include the effect of these angular deviations, it may be assumed that energy loss and deflection occur independently and that boundary effects may be neglected. The Boltzmann equation for the one-dimensional problem is written and the small-angle approximation is made;⁽³⁾ $\cos \theta$ is replaced by $1 - \theta^2/2$ throughout. The angle θ is that between the X axis and the direction of electron travel. Laplace transformations are applied to this equation in the energy-loss variable and in the spatial coordinate, X .

The solution of the transformed equation may be written in terms of the Whittaker function.⁽⁴⁾ The resulting distribution function for the electrons that are proceeding parallel to the X axis at position X may be written as a power series in X , which involves successive derivatives of the Landau function.

Further work is being done on extending the results and evaluating certain of the functions.

⁽²⁾L. Landau, *J. Phys. (U. S. S. R.)* 8, 201 (1944).

⁽³⁾N. C. Wang and E. Guth, *Phys. Rev.* 84, 1092 (1951), Eq. 16 and 17.

⁽⁴⁾E. T. Whittaker and G. N. Watson, Chap. XVI in *A Course of Modern Analysis*, Macmillan, New York, 1943.

HEALTH PHYSICS DIVISION QUARTERLY PROGRESS REPORT

RADIATION DOSE

H. H. Hubbell

INTERNAL RADIATION DOSE

K. Z. Morgan

Radiochemical Analysis (L. B. Farabee). Long-lived alpha activity adhering to filterable airborne particulate matter can be collected on Whatman No. 41 filter disks. Since a chemical assay for the alpha activity on each filter is not practical, a study was made to determine the feasibility of counting the alpha activity directly on the filter. In this study a long-lived alpha-emitting radioisotope on particulate matter was collected on a filter disk and a direct count was made in an alpha proportional counter. The organic constituent of the filter was then destroyed and a chemical assay of the radioisotope was done on the residue. The recovered alpha activity was then counted under standard conditions of known self-absorption.

Nineteen individual samples were determined. The efficiency of counting alpha activity on the paper ranged from 36.0 to 75.0%, with an average of 58.6%. The results showed considerable fluctuation which may be due to varying amounts of carbon and silicates collected on the filters. At present it seems practical to estimate the counting efficiency at approximately 60%.

Spectrographic Analysis of Human Tissue⁽¹⁾ (I. H. Tipton). More than 200 tissues have been analyzed semiquantitatively for B, Co, Au, Mn, Mo, Pb, Cr, Sn, Si, Ni, Bi, Ba, Al, Be, V, Ti, Cu, Cd, Ag, Zn, and Nb. Some 55 bone and cartilage samples (included in the above number) were also analyzed for Fe.

Samples have been submitted to the neutron-activation analysis group for elements where the sensitivity in the spectrographic method is not satisfactory. Test samples indicate about 38 ppm of strontium in bone ash but no detectable strontium in soft-tissue ash. Thirty-one samples of bone ash have been submitted for neutron-activation analysis. Because of the presence of a high concentration of sodium chloride in soft tissue, the spectrographic sensitivity for zinc is very poor. The tissues will be analyzed for zinc by neutron activation.

⁽¹⁾University of Tennessee research and development contract.

EXTERNAL RADIATION DOSE

H. K. Richards

Backscattering of Beta Particles. The experimental results of T. E. Bortner and W. E. Moore are being used to develop a semiempirical theory for the backscattering of beta particles of a number of different maximum energies from scatterers of a wide range of atomic numbers. A comprehensive report concerning the work on this problem during the last two years is in preparation.

Measurement of Ionizing Radiation by High-Frequency Variation. Experiments mentioned in the previous quarterly report⁽²⁾ were continued and the ratio of neutron to gamma response of the instrument for a polonium-boron source was found to be 1.21. A calculation of the order of magnitude showed that one-cycle variation in frequency corresponded to 34 recoil protons.

In addition to experiments with gamma intensities of about 1 to 2 mr/hr, gamma radiation of several hundred milliroentgens per hour was measured by connecting the quartz fiber of the electrometer to a capacitance of 5000 μmf through a 10 megohm resistance. This resistance effectively decoupled the R-F system from the capacitance but permitted the extension of the range for the radiation measurement by the electrostatic coupling.

Investigations have been started with a quartz-crystal-controlled oscillator operated at series resonance. Frequency variations can be produced, as previously mentioned, within a range determined by the ratio of the equivalent series capacitance to the parallel capacitance of the crystal. The variation is produced by the variable capacitance of an electrometer.

Experiments are in preparation that will use ferroelectric materials to replace the electrometer.

X-Ray Dosimetry (H. H. Hubbell, F. H. W. Noll). The project of redetermining the energy dependence of all readily available types of commercial x-ray and personnel-monitoring film has continued. Preliminary runs on four types show a sensitivity that varies by a factor of about 18 as the effective energy of the heavily filtered x radiation is varied

⁽²⁾H. K. Richards, *H-P Prog. Rep.* Jan. 20, 1952 to July 20, 1952, ORNL-1353, p. 8.

from about 25 to 190 kev. This factor appears to be about the same for the four types of film tried, although their absolute sensitivities are quite different.

Tissue Depth Dose for Fast Neutrons (G. S. Hurst, T. A. Barr, Jr.). The measurements of the dose resulting from fast neutrons in a large, cylindrical tank, 30 cm thick and 200 cm in diameter, filled with tissue-equivalent solution, have been practically completed and a report is being prepared. The results show good agreement with the Monte Carlo calculations of W. S. Snyder and indicate a relaxation length of about 7 cm for polonium-boron neutrons in tissue. The ratio of total dose to first-collision dose in tissue is about 2, which is in agreement with the calculations.

Shielding (R. H. Ritchie). The preparation of two chapters on maximum permissible exposures and on the scattering of gamma and neutron radiations from various shielding structures, etc. for the "Reactor Handbook" has continued.

Film Monitoring for Fast Neutrons (J. S. Cheka). Work has been done on the modification of the NTA film packet to make it a fast-neutron dose meter. NTA emulsion is rather insensitive to gamma radiation but records the passage of heavy ionizing particles such as recoil protons. A minimum proton energy of 0.25 Mev is required to form a recognizable tract of three grains. In its present state, the film measures neither flux nor dose accurately. After a calibration is made on a batch of film, neutron exposure can be evaluated by that batch only if the energy spectrum of neutrons is the same as that of the source used for the calibration.

The fast-neutron response of the film consists of three parts: (1) protons with energies greater

than 0.25 Mev that are formed in the emulsion, (2) protons formed in the cellulose acetate base of the film that reach the emulsion with energies greater than 0.25 Mev, and (3) protons formed in the film wrapper or other extraneous hydrogenous material that reach the emulsion with residual energies greater than 0.25 Mev.

The tissue-dose curve to be fitted is based on W. S. Snyder's calculations of fast-neutron energy loss in tissue. When the resultant curves from parts (1) and (2) of the fast-neutron response are added, they fit the tissue-dose curve fairly closely up to 5 Mev. Beyond this point the sum falls below the dose curve. Calculations are being made on a proton radiator that corresponds to part (3) of the fast-neutron response. It will consist of a plastic and a nonhydrogenous filler selected to give a rate of proton production and proton range that will permit just sufficient protons with energies greater than 0.25 Mev to reach the emulsion to make up the deficiency at higher energies.

Energy Losses of Electrons in Foils (R. D. Birkhoff, A. W. Smith, J. Bergstein). A small accelerator has been designed and constructed for use in measuring the energy losses, in foils, of electrons with energies up to 250 kev and for the program of radiation dosimetry using complex molecules. Extensive help has been given by R. W. Bennett and R. F. King of the High-Voltage Laboratory.

A stopping-potential type of energy analyzer is being designed that will permit the study of the particle energy distribution resulting from the passage of the beam through thin layers of absorbing gases and solids. Preliminary performance data indicate a probable energy resolution in the analyzer of 5 ppm.

PHYSICS OF NUCLEAR RADIATION

G. S. Hurst

IONIZATION BY ALPHA PARTICLES

T. E. Bortner

The W value for helium of extremely high purity is approximately 42 ev per ion pair. This value, as well as the values for helium and argon,⁽¹⁾ must be considered as preliminary until further experi-

⁽¹⁾T. E. Bortner and G. S. Hurst, *H-P Prog. Rep.* Jan. 20, 1952 to July 20, 1952, ORNL-1353, p. 22.

mental work is completed. A heating unit has been placed on one chamber port (between the calcium trap and the ion chamber) and a liquid-nitrogen trap on the other. In this way a temperature differential of about 500°C is attained that substantially aids the convection of gas through the calcium chamber.

A slyphon pump has been designed and placed on the calcium trap to pump gas through the ion chamber. The pump is now being tested.

HEALTH PHYSICS DIVISION QUARTERLY PROGRESS REPORT

MEASUREMENT OF THE ELECTRON- ATTACHMENT COEFFICIENT FOR VARIOUS GASES

W. G. Stone

A knowledge of the probability of an electron attaching itself to a neutral heavy atom is of considerable importance in the prediction of the behavior of ionization chambers and counters. The quantity that is most easily measured is the probability of an electron becoming attached while moving a distance of 1 cm in a gas under a known electric field. This also is the quantity needed for ionization-chamber work, but in order to make certain theoretical deductions the probability of attachment per collision is needed. In order to know the coefficient (probability) per collision, the drift velocity of electrons under the same conditions must be measured.

An ionization chamber and associated purification chamber for making this measurement is being designed and built by Abele and Knowles of the Instrument Department. The design is 80% complete and the construction is 10% complete. The chamber is designed to measure both electron-attachment coefficient and electron-drift velocity. Where the nature of the gas permits, the two measurements can be made simultaneously.

The chamber and all associated equipment with which the gas under measurement will come in

contact will be constructed of stainless steel, Teflon, and Fluorothene. The only exception will be the material in the purification chamber that will be used to remove traces of impurities from the gas under test. When testing the noble gases and most organic gases, the purifying medium will be metallic calcium.

R. Baldock advised against the use of available stainless steel valves because they have cast bodies that are difficult to outgas, so special valves are being designed and built by Hensley of the Engineering Department. The design is 98% complete and construction is scheduled to begin soon.

The special preamplifier that is required for the equipment is being designed and built by Adams of the Instrument Department. The design is 75% complete.

DOSIMETRY FOR ANIMAL EXPOSURE

W. T. Ham
G. S. Hurst

M. Slater
J. A. Auxier⁽²⁾

All the dosimetry measurements indicated in the previous quarterly report for animal exposures have been completed. A detailed report of the results is in preparation.

⁽²⁾In cooperation with the University of Texas, Austin, Texas.

EDUCATION, TRAINING, AND CONSULTATION

E. E. Anderson
M. F. Fair

M. R. Ford
T. H. J. Burnett

AEC FELLOWSHIP PROGRAM

The 1951-52 group of AEC Fellows in radiological physics completed their field training at the Oak Ridge National Laboratory on August 30. Nine of the Fellows were granted six-month extensions of their fellowships to complete a research problem in fulfillment of the requirements for a Master's degree from Vanderbilt University. One Fellow was granted a 12-month extension for study at Harvard University in the field of industrial hygiene. The remainder of the Fellows accepted jobs in the field of health physics with the exception of two who are continuing their graduate work.

The new group of AEC radiological Fellows (22 in number) began work at Vanderbilt University on September 22.

TRAINING PROGRAM FOR AEC CONTRACTORS' PERSONNEL

Three of the four DuPont employees completed their training and have been transferred to Aiken, South Carolina. The other employee, who is a sanitary engineer, has completed the routine field training and is working in the waste-disposal section. One employee of ORINS Medical Division spent a month with the section for training in routine survey work.

CONSULTATION

One member of the section has been on loan to the University of Pittsburgh to make a survey of current practices in the monitoring and control of airborne radioactive particles.

EXPERIMENTAL RADIATION MEASUREMENTS

F. J. Davis
C. F. Harris

J. A. Harter
P. W. Reinhardt

URANIUM PROSPECTING⁽¹⁾

A scintillation counter that is designed to be mounted on an automobile luggage rack has been developed for use in uranium prospecting and radiation surveys. The 1 by 2½ in. sodium iodide crystal used is shielded against radiation from the road but is sensitive to radiation sources on both sides of the road. The chart-drive mechanism of an Esterline-Angus recorder has been coupled to the speedometer shaft of the automobile so that the travel of the chart is proportional to the travel of the car, and is independent of speed. Also, an edge marker is connected to the odometer so that a single edge mark occurs each mile, a double edge mark every ten miles, and a triple edge mark every one hundred miles. There is an additional edge marker on the opposite edge of the chart that

can be operated by a hand switch to record the chart positions of reference land marks. The circuits are powered by dry batteries that have a service life of approximately 1000 hours. The apparatus has been operated in Colorado and Wyoming areas by the U. S. Geological Survey and has proved to be superior to the Geiger-counter apparatus previously used. Improvements being developed by the U. S. Geological Survey include a two-channel system that gives independent records from two crystals, each responding to radiation from only one side of the road.

An additional aircraft of the C-47 class has been allocated and is awaiting delivery to the U. S. Geological Survey for use in uranium prospecting. Conversion of the plane is expected to be complete early in the spring of 1953. The radiation equipment will be essentially the same as that in the present DC-3 aircraft. The aircraft will be used part time for radiation surveys at the Oak Ridge National Laboratory.

⁽¹⁾In cooperation with the U. S. Geological Survey.

AIRBORNE RADIOPARTICULATE CONTAMINATION

E. G. Struxness
W. D. Cottrell
R. L. Bradshaw

J. W. Thomas
B. G. Saunders
E. E. Grassell

RADIOACTIVE-PARTICLE PROGRAM AND PEEP

The physical transfer of personnel and equipment, formerly associated with PEEP under the direction of E. D. Shipley, to ORNL Health Physics Division at X-10 is essentially complete. A few minor alterations and additions to the present laboratories remain to be accomplished.

The continuous-action Wilson apparatus, on loan from H. L. Green of the Chemical Defense Experimental Establishment at Porton, Down, England, has been received. The apparatus, together with the associated photographic equipment, is being assembled and adapted for use in counting small particles, particularly those that may penetrate highly efficient particulate filters. Other equipment for penetration studies has been reassembled in the laboratory and the preliminary operational adjustments are in the process of completion.

A study of all the available data, published and unpublished, pertaining to the so-called "particle" problem at ORNL has been initiated and a proposal for further evaluation of this problem will be submitted.

A device that measures and records particle size, based on the light scattering properties of small aerosol particles, has been developed. Although the device is usable at the present time, other improvements are planned. A servo controller for maintaining constant particle size in the DOP aerosol generator is also under development.

An investigation of the variables affecting operation of the DOP aerosol generator is now under way. Another diffusion battery, shorter in length, has been fabricated. It will be used in conjunction with the longer battery previously tested and will give information on the discrepancies that may possibly result from end-effects.

PUBLICATIONS

1. W. J. Lacy, *J. Am. Water Works Assoc.* **44**, 824-828 (September 1952).

2. R. J. Morton, *Civil Eng.* **22**, 138-141 (September 1952).

3. H. R. Craft, J. C. Ledbetter, and J. C.

Hart, *Personnel Monitoring Operating Techniques*, ORNL-1411, October 1952.

4. E. D. Klema and R. H. Ritchie, *Phys. Rev.* **87**, 167 (1952).

5. E. D. Klema, R. H. Ritchie, and T. I. Arnette, ORNL-1398 (classified report).