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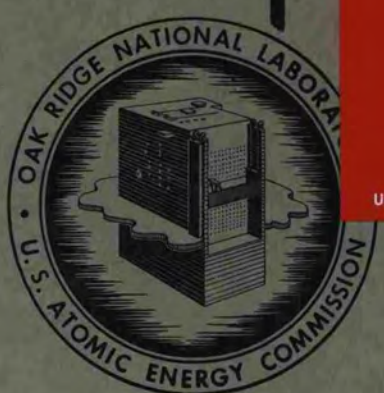
# HEALTH PHYSICS DIVISION

# QUARTERLY PROGRESS REPORT

## FOR PERIOD ENDING JANUARY 20, 1952



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# HEALTH PHYSICS DIVISION

K. Z. Morgan, Director

# QUARTERLY PROGRESS REPORT

## for Period Ending January 20, 1952

DATE ISSUED

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M. W. Carter
W. J. Lacy
D. A. Pecsok
O. R. Placak
C. P. Straub

**Trickling Filter Study with Urine Waste Containing Radioactive Iodine.** A study is in progress to determine whether $I^{131}$, which is contained in the urine discharged from patients treated with radioactive iodine, can be removed from sewage by trickling filters. In previous studies it has been found that trickling filters can remove carrier-free $I^{131}$ from sewage up to about 85% when the flow rate does not exceed two million gallons per acre per day. Much lower removals were obtained when double the flow rate was used with the carrier-free iodine, and still lower removals were obtained at this higher flow rate when the carrier potassium iodide was added to the $I^{131}$ solutions.

The present study is designed to evaluate the effects or urine and the other constituents of hospital wastes upon the removal of radioactive iodine by trickling filters and should permit a comparison with the results of the previous experiments. Four trickling filters will be used, each 6 ft long and 2 in. in diameter. The urine waste obtained from the Oak Ridge Hospital will be added to domestic sewage for continuous dosage to two of the test filters. The third filter will receive sewage containing carrier-free $I^{131}$, and as a control the fourth filter will receive plain settled sewage.

**Removal of Radioisotopes from Water by Metallic Dusts.** The removal of various isotopes from solution by slurries of metallic dust has been studied. Representative data, taken from a report now in preparation, are reproduced in Table 1. The data given indicate the removals by using only a 500-ppm dose of various metallic dusts and a 90-min period of contact mixing followed by settling. Other mixing times and dosage rates not included in the table were also investigated.

The effect of a larger amount of a metallic dust may be seen. By using 2000 ppm of iron dust, with a 90-min contact period, better removals, in general, were obtained. The only metallic dust used with $Y^{91}$ was zinc; for 90 min of contact time and 2000 ppm of dust the indicated removal was 99.1%, compared with 97.5% for 500 ppm of dust.

### SURVEY STUDIES AND ECOLOGICAL STUDY OF WHITE OAK CREEK DRAINAGE AREA

E. R. Eastwood
J. M. Garner
V. I. Knobf
L. A. Krumholz
W. T. Miller
R. L. Nichols

**Radioactivity in Fish and Other Aquatic Animals.** The study of fish in White Oak Lake to determine seasonal differences in the radioactivity in various tissues has been continued. This study is accomplished by weekly collection, dissection, and analyses of three fish of each of two species that are prevalent in White Oak Lake. Preliminary indications imply that the

TABLE 1

Percentage of Removal of Indicated Radioisotopes from Water by Treatment with 500 ppm of Metallic Dusts for 90 Minutes

| ISOTOPE | PERCENTAGE OF REMOVAL | | | | | |
|---|---|---|---|---|---|---|
| | Zn | Cu | Al | Mg | Fe | Fe (2000 ppm) |
| $Ru^{106}$-$Rh^{106}$ | 99.2 | 84.0 | 92.5 | 95.9 | 99.1 | 99.1 |
| $Y^{91}$ | 97.5 | | | | | 99.1 |
| $Zr^{95}$-$Cb^{95}$ | 98.5 | 97.5 | | | 98.9 | 99.8 |
| $P^{32}$ | 98.6 | | 81.8 | | 99.6 | 99.7 |
| $Cs^{137}$ | | | | | 4.9 | 14.7 |
| $Ta^{182}$ | 91.6 | | 99.9 | | 99.9 | 99.8 |
| $I^{131}$ | 48.7 | 32.0 | 22.5 | | 22.0 | 54.0 |
| $Ce^{144}$-$Pr^{144}$ | 99.9 | 99.5 | 99.9 | | 99.9 | 99.8 |

accumulation of radioactivity in bone, flesh, and other tissues of the fish is much greater during the warm months than during the winter season.

A study has been initiated during this period to obtain data on the accumulation and distribution of radioactivity in waterfowl. The primary purpose at this time is to make a preliminary appraisal of the importance of this problem and to establish the proper procedures for a more systematic study of waterfowl on White Oak Lake if such further study is indicated. To date, a total of six specimens, four coots and two ducks, have been collected and analyzed. The preliminary data indicate that levels of radioactivity in the flesh and other tissues of the waterfowl examined are significant and are generally similar to those found in fish tissues. Present data are insufficient for definite conclusions, and work on this project is to be continued.

**Radioactivity in River-Bottom Sediments.** The results of a survey of the activity in river-bottom sediments, obtained by "flounder" measurements of cross sections of the river, are plotted in Fig. 1. These measurements were made by lowering from a boat the subsurface Geiger-Mueller-tube scanning instrument, "flounder," which has been discussed in previous reports. The readings at Tennessee Mile 575 and above are upstream from any possible influence from installations at Oak Ridge and fall generally within the normal range of background. Slight increases are noted in the Tennessee River below the junction with the Clinch River. These increases disappear directly below each of the dams because of the scouring action on the river bottom caused by increased velocity. Although these sections are shown as dotted lines in Fig. 1, a sufficient number of spot checks were made to establish the validity of the decreases in activity below the dams.

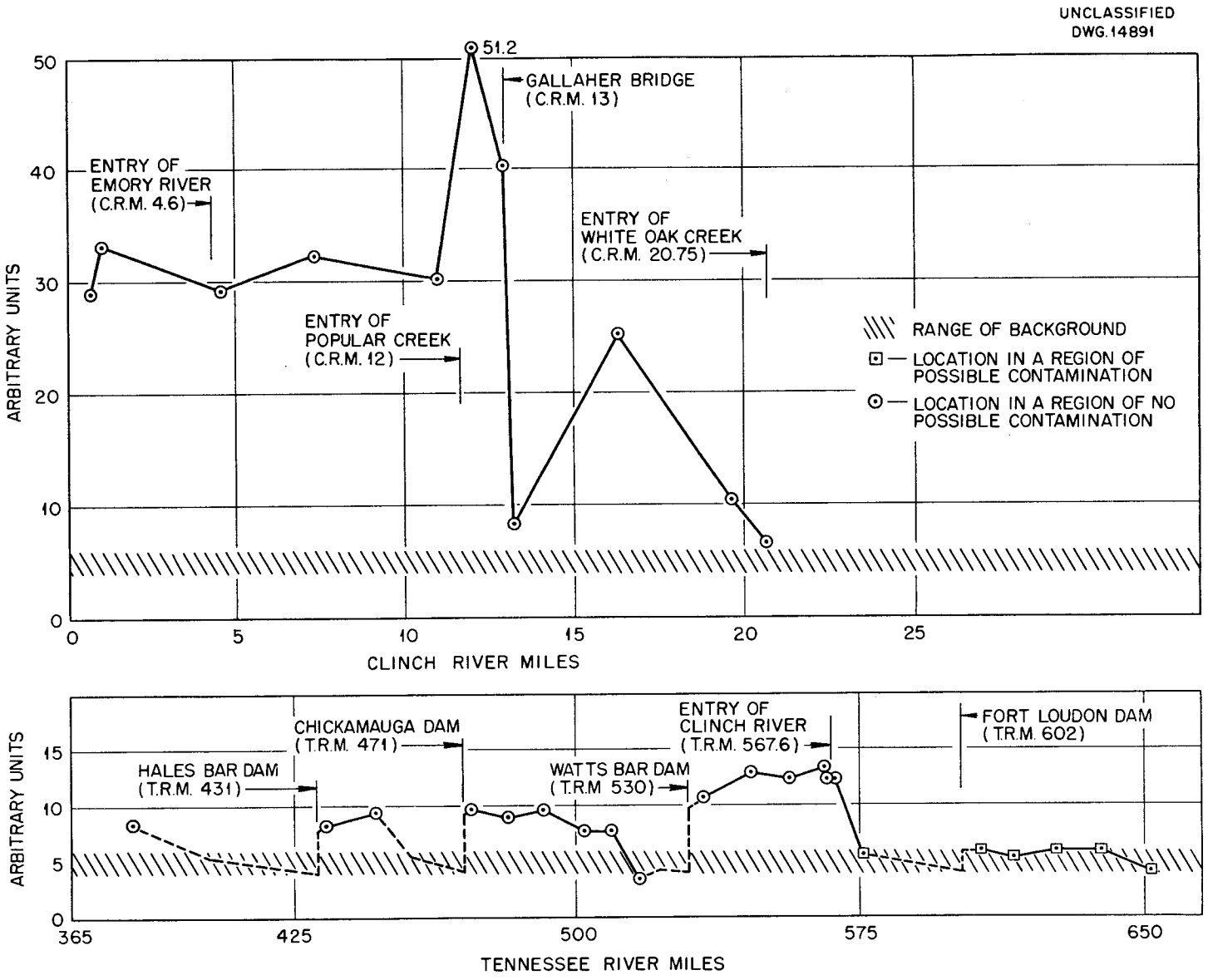


**Fig. 1. Weighted Average Concentration of Radioactivity in River Sediments.**

The reading obtained at the point directly above Gallaher Bridge on the Clinch River appears to be too low. A higher value would normally be expected because the river narrows in this stretch, and the low value here is probably the result of increased velocity with consequent scouring and unfavorable conditions for the deposition of sediment.

### INSTRUMENTATION AND TECHNIQUES

J. M. Garner  O. W. Kochtitzky
R. A. Lauderdale

**Low-Level Measurements of Radioactivity in Water.** The development and use of a column type of water monitor that employs a 10-in. glass Geiger-Mueller tube surrounded by a bed of ion-exchange resin has been continued. This device is now being used to measure activity levels of natural ground and surface waters and of rain water collections in the vicinity of Oak Ridge. Experience with it has been amplified by the counting of more than 150 such water samples. It is capable of measuring activities in the order of $10^{-7}$ $\mu$c/ml in the absence of large quantities of nonradioactive soluble salts.

## THEORETICAL PHYSICS

J. Neufeld  W. S. Snyder

### FAST-NEUTRON TOLERANCE CALCULATIONS

In the previous quarterly report the damage caused by energy losses of a beam of neutrons normally incident on a 30-cm slab of tissue has been reported for incident energies of 10, 5, 2.5, and 0.5 Mev. Since many of the neutrons thermalize in the slab, there is further damage resulting from the absorption of thermal neutrons. This damage has been calculated on the basis of the data of the Monte Carlo procedure. The thermal damage is quite negligible at high energies, being less than 1%, but it becomes appreciable at lower energies. To confirm this, an incident beam of 0.005 Mev was calculated, and the damage caused by thermal effects was found to be about 60% of the total damage. The maximum permissible flux for neutrons of this energy is now being calculated and seems to be about 1500 neutrons/cm$^2$/sec to give 0.3 rep in 40 hours. A detailed report on the problem is being written.

### DISTRIBUTION OF ENERGY LOSSES OF MOVING IONS

The density of energy loss as a function of distance from the track of a proton moving in tissue has been calculated for velocities of $5w$, $10w$, and $20w$ ($w = e^2/\hbar$), where $w$ is measured in centimeters per second. A report of these results is being prepared.

# PHYSICS OF NUCLEAR RADIATIONS

H. K. Richards

## FAST-NEUTRON POCKET METER INVESTIGATION

J. S. Cheka

A series of measurements has been made on a chamber lined with polyethylene and having a polyethylene central electrode (both Aquadag-coated) in order to compare this with the beryllium- and graphite-lined chambers that have been previously reported.

Table 2 shows some results of exposure to radium gamma and neutron radiation and to the associated gamma radiations from polonium–boron and polonium–beryllium sources. The chambers were charged to 250 v (zero on the minometer scale) and can be read down to 90 v (250 on the minometer scale). The figures given are the minometer scale readings that are the averages of several exposures. The chambers were filled with air at atmospheric pressure.

**TABLE 2**

**Minometer Readings of Chambers Exposed to Indicated Radiation**

| EXPOSURE | CHAMBER WALL | | |
|---|---|---|---|
| | BERYLLIUM | GRAPHITE | POLYETHYLENE |
| 100 mr Ra $\gamma$ | 35.0 | 35.4 | 35.4 |
| 300 mr Ra $\gamma$ | 105 | 106.5 | 106.5 |
| $10^7 n_f$ Po-B | 5.07 | 4.25 | 15.48 |
| $10^7 n_f$ Po-Be | 8.45 | 6.08 | 20.58 |

In monitoring for neutrons, chambers that give an equal gamma-radiation response should be used in pairs: one of the least responsive to neutrons, the graphite-lined chamber, paired with one of the most responsive, the polyethylene chamber. The neutron exposure would be determined by the difference in response. Thus, in the case of polonium–boron neutrons, a week's permissible exposure of $10^7 n_f$ would give a minometer reading of about 10% of that produced by a week's permissible exposure to radium gamma radiation, or its equivalent. In the field such exposures could easily occur simultaneously; thus, the neutron flux would have to be evaluated as a rather small difference in the total reading. Tests have shown that the ratio is improved to approximately 15% by the use of helium as the filling gas, but no study of the feasibility of using helium in pocket chambers has been made.

Another series of measurements was made at progressively lower air pressures, down to about 6 mm of Hg. As zero pressure was approached, both the graphite- and the polyethylene-lined chambers showed responses that approached zero in approximately a linear fashion. This would imply no measurable heavy-atom (carbon) ionic current. The response of the beryllium-lined chamber did not approach zero, but it approached a value between 1 and 2% of the response at normal pressure for both neutron sources. Since the neutron response of this chamber is more than 20% greater than that of the graphite-lined chamber at normal pressure, it appears that, although some beryllium atoms are given sufficient energy by fast-neutron collision to ionize, this effect is relatively small; and the major part of the added response is from the $Be^9$ $(n,\alpha)$ $He^6$ reaction.

Test tubes containing 10 ml each of carbon disulphide were exposed to

polonium–boron neutrons. Sulfur in the compound reacted as follows:

$$S^{22}\ (n,p)\ P^{32}\ .$$

The phosphorus so formed remained dissolved in carbon disulphide; the solution was transferred to counting dishes, evaporated, and then counted at 10% geometry. The results appear in Table 3.

This test is not sensitive enough for personnel monitoring, but it may serve for evaluation of exposure in an atomic disaster.

**TABLE 3**

**Phosphorus$^{32}$ Formed by Neutron Bombardment of Carbon Disulphide**

| $n_f/cm^2$ | TOTAL c/min* (above background) | $c/min/10^7 n_f$ |
|---|---|---|
| $9.19 \times 10^8$ | 32 | 0.35 |
| $5.87 \times 10^8$ | 20 | 0.34 |
| $2.61 \times 10^8$ | 12 | 0.46 |
| $1.33 \times 10^8$ | 1 | 0.08 |

*Dishes were counted for 5 minutes.

## MEASUREMENT OF IONIZING RADIATION BY FREQUENCY VARIATION OF AN RF OSCILLATOR

Experiments with a quartz fiber suspension for the electrometer leaf of the variable capacitance showed satisfactory results, but the mechanical vibrations of the system represent an undesirable interference; hence, new construction is under way to reduce these vibrations.

## BETA PARTICLES

T. E. Bortner

The range of beta particles of $P^{32}$ has been established in seven different absorbers, including aluminum. This work was done with a standard thin-window counter, lead shielding, and a 1024 scaler. The results obtained, with a probable error of ±10 mg/cm$^2$, are as follows:

| ABSORBER | RANGE (mg/cm$^2$) |
|---|---|
| Beryllium | 863 |
| Carbon | 800 |
| Aluminum | 800 |
| Copper | 700 |
| Tin | 660 |
| Tantalum | 630 |
| Lead | 620 |

## STRAGGLING OF CONVERSION ELECTRONS FROM BARIUM$^{137}$ AS MEASURED WITH THE SOLENOIDAL SPECTROMETER

R. D. Birkhoff F. Kalil

Experimental work with the solenoidal beta spectrometer has been completed. The measurements that were made of straggling and absorption of 626 kev beta rays in foils of various thicknesses and atomic numbers have been used by an AEC fellow in radiological physics as a basis for his master's degree thesis at Vanderbilt University. Publication of a laboratory report is being delayed pending further analysis and interpretation of the data by several members of the Health Physics Division and the Mathematics Panel.

## CALIBRATION OF MONITORING EQUIPMENT

W. J. O'Brien

Another AEC fellow finished the installation and calibration of monitoring equipment in the State of Tennessee mobile radiological laboratory. This work also will be used to satisfy the thesis requirement for the master's degree at Vanderbilt University.

## SKIN FLUORESCENCE AFTER X AND GAMMA IRRADIATION

R. D. Birkhoff

A new project has been started by the Health Physics Division in cooperation with the University of Tennessee Physics Department. The fluorescence of human skin under ultraviolet light after exposure to x or gamma radiation is being studied with regard to application to dosage measurements.

## EXPERIMENTS ON BETA-RAY BACKSCATTERING

W. E. Moore

A $2\pi$ beta proportional gas-flow counter is being used to study the backscattering of beta rays from several different materials. The chamber has been removed from the scalar, inverted, and the handle replaced by a 0.6-mg/cm$^2$ rubber hydrochloride window, coated with Aquadag. The source consists of a small spot of $P^{32}$, which is deposited on the upper side of this window and, therefore, outside the counting chamber. Backscattering materials are then placed above the source by using separation rings to vary the distance.

To study the variation of backscattering with thickness a series of measurements were taken by using thin leaves of gold and aluminum. The curves were plotted with the ratio of the backscattered radiation to the original radiation in percentage as the ordinate and the mg/cm$^2$ of the backscatterer as the abscissa. Thin leaves of aluminum, weighing 0.14 mg/cm$^2$, and of gold, weighing 0.18 mg/cm$^2$, were used to study single scattering. When thicker pieces were used, multiple scattering resulted and the curves were made concave downward. Figure 2 shows that single scattering predominates to a thickness of 1 mg/cm$^2$ for gold and to a thickness of 2.3 mg/cm$^2$ for aluminum. As the thickness was increased further, the ratio of backscattered radiation to original radiation reached a constant value (saturation backscatter value). This value varied with the atomic number of the scatterer. Thick pieces of 18 elements were investigated, and saturation values were plotted against the atomic number of each.

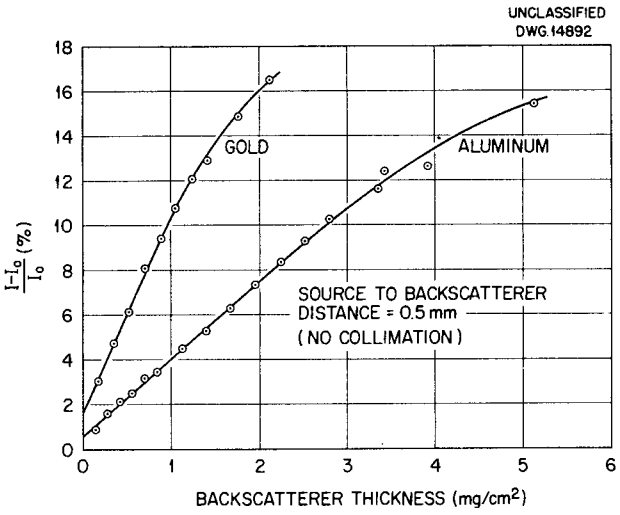


**Fig. 2. Phosphorus$^{32}$ Backscattering Curves for Aluminum and Gold Leaf.**

Collimators were constructed from polyethylene and aluminum so as to give "thickness" a more accurate meaning by limiting the maximum angle of backscattered radiation. The curves were repeated by using these collimated sources. Figures 3 and 4 are typical curves.

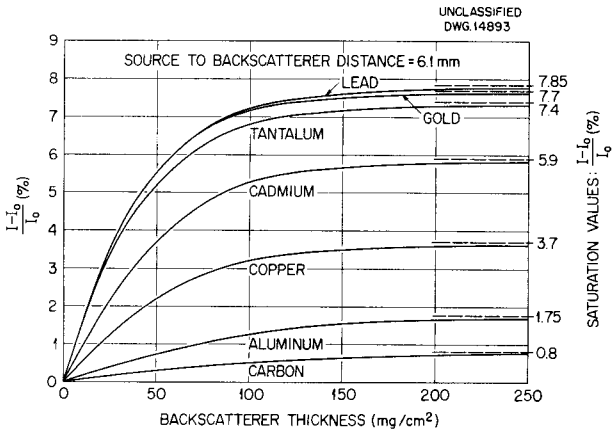


**Fig. 3. Backscattering Curves for Phosphorus$^{32}$ with Collimation.**

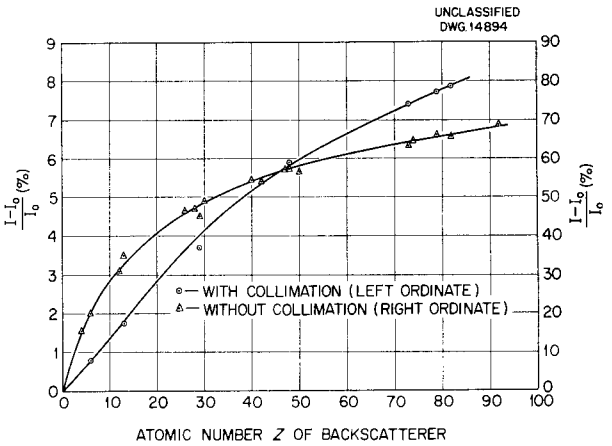


**Fig. 4. Saturation Backscattering vs. $Z$ for Phosphorus$^{32}$.**

## RADIOCHEMICAL ANALYSIS

L. B. Farabee

### ANALYTICAL PROCEDURE FOR DETECTING PLUTONIUM IN RIVER WATER

There exists a need of a procedure for the analysis of river and stream water for plutonium. This is of special interest to the Oak Ridge National Laboratory, since water from White Oak Lake is discharged into the Clinch River. The procedure now in use is unsatisfactory because of the difficulty of separating plutonium from iron and other inorganic constituents of the sample. Also, indeterminate self-absorption of alpha radiation results from the plating of extraneous inorganic materials with plutonium. Some preliminary work has been done that was reported in ORNL-968.[1]

Recent exploratory tests have resulted in the development of an analytical procedure that is fairly quantitative and reproducible. In 14 determinations the average recovery was 92.0%, with a maximum deviation of ±4.7%.

[1] *Health Physics Division Quarterly Progress Report for Period Ending January 20, 1951*, ORNL-968.

# PHYSICS OF RADIATION DOSIMETRY

H. H. Hubbell

## X-RAY DOSIMETRY

A project to determine the saturation effects of various x-ray dose rates on pocket ionization chambers at various charging voltages has been started.

Personnel monitoring film badges in current use are energy-dependent, and to determine their actual exposure, readings from them must be interpreted in relation to the energy of the radiation affecting them. In the hope of developing a film monitoring device that is not energy-dependent, preliminary exposures on a film badge having filters of iron, cadmium, and lead have been made by using a 250-kv x-ray machine.

One member of this section is representing the Laboratory on the subcommittee on x-ray sensitometry of the American Standards Association. This committee is attempting to standardize techniques for calibrating film used for personnel monitoring and is also writing a sensitometric standard for x-ray film.

## TISSUE DEPTH DOSE FOR FAST NEUTRONS

G. S. Hurst

Apparatus has been designed and partly constructed for the purpose of measuring the dose resulting from fast neutrons at various depths in tissue. The neutron source will be the deuteron-deuteron reaction. Measurements will be made by using a tissue phantom consisting of water, urea, and sucrose. The small-diameter proportional counters to be used as dosimeters have been completed.

## FAST-NEUTRON DOSIMETER

A contract has been let for the commercial production of fast-neutron count-rate dosimeters of the type previously described. The contractor reports satisfactory progress, and the first 26 instruments should be delivered about April 1, 1952.

## PROPORTIONAL-COUNTER DEVELOPMENT

G. S. Hurst  R. H. Ritchie

The equation that describes the shape of a proportional-counter pulse arising from an extended track of ionization in the counter after the pulse has been amplified in a linear amplifier has been evaluated by the Mathematics Panel for various values of track extension and positive-ion collection time.

The results show that the maximum height of the output pulse is essentially independent of the length and position of the track in the counter as long as the ratio of the time of collection of the electrons from the track to the amplifier time constant is not greater than unity. This work will be described completely in a forthcoming paper.

## PHYSICAL CALCULATIONS

R. H. Ritchie

A program of shield measurements and air-scattering calculations has been suggested and reported in CF-51-8-7.[2] Calculations have been made

[2] J. L. Meem and R. H. Ritchie, "Suggested Program for Divided Shield Measurements and Calculation of Air Scattering," CF-51-8-7 (August 1, 1951).

of the efficiency of a sodium iodide scintillation counter for a distributed source of beta and gamma rays. Comparisons have been made and reported in CF-51-10-203[3] of gamma-ray dosage measurements that were made with a standard gamma-ray chamber[4] and those that were made with a gamma-ray spectrometer.[5] Calculations are now in progress on the loss in pulse height in a scintillation crystal owing to the formation of Bremsstrahlung through the walls of the crystal.

Calculations are in progress on the effective radius of a beta source in the presence of a scattering foil in a beta spectrometer of the type used by Birkhoff.[6]

An expression has been derived for the temperature in a moving medium owing to a stationary volume distribution of sources that vary in strength with time. This expression is a generalization of one given by Carslaw and Jaeger[7] and has been applied to a problem considered by Podolsky.[8,9]

## BIOPHYSICS

M. Slater

Preliminary work has been done toward setting up a project to study the direct action of charged particles on enzymes and other substances of biological interest. A literature survey has been made on the biological and chemical effects of ionizing radiation. An alpha-particle source and a bombardment chamber are being designed for experimental work. Also in the design stage is a tube for bombarding the substances mentioned with electrons of energies up to 250 kv, principally by using equipment already available in the division or the Laboratory.

(3) R. H. Ritchie, "Tentative Comparison of Ionization Chamber and Spectrometer Measurements at the Bulk Shielding Facility," CF-51-10-203 (October 31, 1951).

(4) L. H. Ballweg and J. L. Meem, "A Standard Gamma-Ray Ionization Chamber for Shielding Measurements," ORNL-1028 (July 9, 1951).

(5) J. K. Bair, F. Maienschein, and William Baker, "Multiple Crystal Gamma-Ray Spectroscopy Using NaI-ThI Crystals," NEPA-1701 (February 13, 1951).

(6) R. D. Birkhoff, "Distribution of Energy Loss of Electrons in Aluminum," *Phys. Rev.* 82, 448 (1951).

(7) H. S. Carslaw and J. C. Jaeger, *Conduction of Heat in Solids* (Oxford: Clarendon Press, 1949), p. 223.

(8) Boris Podolsky, "A Problem of Heat Conduction," *J. Applied Phys.* 22, 581 (May 1951).

(9) R. H. Ritchie, "The Temperature Function in a Moving Medium," *J. Applied Phys.* 22, 1389 (November 1941).

# EDUCATION AND TRAINING

E. E. Anderson
M. F. Fair M. R. Ford

## AEC FELLOWSHIP PROGRAM

The present group of 19 fellows in radiological physics began their academic work at Vanderbilt University September 24, 1951. Their records for the first quarter are highly satisfactory.

## TRAINING PROGRAM FOR AEC CONTRACTORS PERSONNEL

Five employees of the DuPont Company have been with this section for training during this period, and four American Cyanamid employees have continued their training. One AEC employee spent two weeks with this section observing field practices in health physics.

## LECTURES AND SEMINARS

One seminar on health physics was conducted for the Oak Ridge Institute of Nuclear Studies and one lecture on nuclear physics was given for the Naval Reserve seminar. Lectures on radiation hazards were given at the following institutions as participation in the Traveling Lecture Program of ORNL: University of Mississippi, University of Arkansas, University of Oklahoma, Virginia Polytechnic Institute, and Radford College. An informal conference with science majors was held at Hollins College, Roanoke, Virginia.

## MISCELLANEOUS ACTIVITIES

Members of the staff continue to assist in other teaching activities in the Laboratory by giving two courses in mathematics in the Apprentice Training School and a course in nuclear physics in the ORNL Staff Education Program.

Considerable time during this period has been devoted to reviewing reports written by members of the division and in writing the section on health physics for the textbook on reactor engineering.

# EXPERIMENTAL RADIATION MEASUREMENTS

F. J. Davis

## VARIATIONS IN THE RADIUM AND RADON CONTENT OF THE CLINCH RIVER

L. F. Garcia

Measurements were made on the radon and radium content of water samples taken daily from a fixed point on the Clinch River, from October 30 through December 11, 1951. Briefly, the method consists in transferring the radon in a 1500-cc water sample to an evacuated ion chamber by boiling the water and bubbling nitrogen through it. The amount of radon is determined by counting the pulses produced in the chamber by the alpha particles of radon in equilibrium with radium A and radium C. The radium content is determined indirectly by measuring the amount of radon collected in the water sample during a period of approximately 12 days.

This investigation showed (see Fig. 5) that both the radon and radium content increase considerably after a local rainfall. The radon content was found to vary between $0.73 \times 10^{-12}$ and $7.75 \times 10^{-12}$ curie/liter, and the radium content varied between $1.4 \times 10^{-14}$ and $14.0 \times 10^{-14}$ curie/liter. A consistently high radon/radium ratio – as high as 153 in one day – was observed. There were several instances that seemed to indicate water temperature as an additional cause of the variations in the radon content; however, this was not conclusive.

## VARIATIONS IN THE NATURAL RADIOACTIVITY OF THE FREE ATMOSPHERE AT ORNL

W. C. King

A study of the meteorological influences on the radon and thoron concentrations in the air was made by counting with two scintillation detectors the radium C and C′ and thorium C and C′ alpha activity deposited on a moving filter. The measurements were separated by a 4-hr time interval. Plots of the diurnal variations of the data collected over several months show excellent correlation with temperature inversions, wind velocity, and relative humidity. Stable air near ground level that exists during a temperature inversion and low-wind velocity favors high concentrations of radon and thoron. Turbulent air, which is produced by high winds or which exists on clear sunny days, produces a minimum in the concentrations. The values may vary by a factor of 5 or 10 during the day. Prolonged dry spells are more favorable to higher peak concentrations than are wet periods. The values have been observed to vary by a factor of 22 between the maximum peaks obtained during a dry period and the minimum peaks obtained during a wet period. The average value found for the radon concentration in air during a two-month period was $1.2\ (10)^{-16}$ curies/cc, with the value of thoron averaging about 3% of that of the radon.

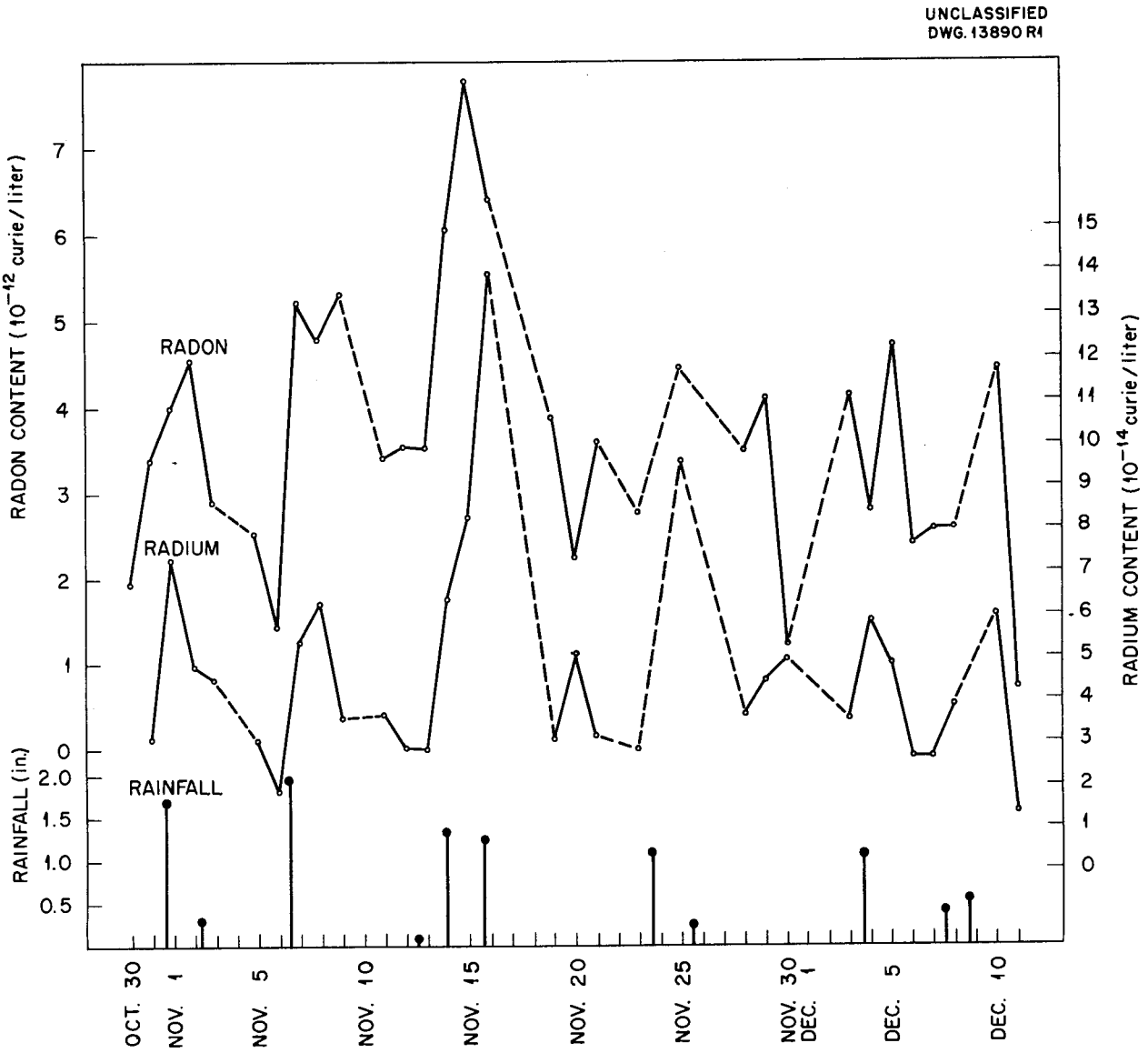


**Fig. 5. Local Rainfall and the Radium and Radon Content of the Clinch River.** From thesis by Luis F. Garcia, under the direction of Dr. Francis J. Davis - "Variations in the Radium and Radon Content of the Clinch River."

## PERMISSIBLE INTERNAL DOSE - RADIOISOTOPES

K. Z. Morgan

### UNIVERSITY OF TENNESSEE RESEARCH AND DEVELOPMENT SUBCONTRACT

I. H. Tipton

Twenty-one samples each of human liver, kidney, heart, skeletal muscle, and bone (in most cases vertebra) have been received by the spectrographic laboratory at the University of Tennessee in Knoxville from the Deaconess Hospital pathology department, Boston, Massachusetts. One complete autopsy consisting of samples of human liver, kidney, heart, skeletal muscle, bone, brain, lung, pancreas, spleen, thyroid, gonads, stomach, and intestine have been received from the Ohio State pathology department, Columbus, Ohio. The pathology departments of the University of Alabama, College of Medicine at Birmingham, Alabama, and the University of Tennessee College of Medicine, Memphis, Tennessee, are also cooperating with the program.

The present analytical technique employed in the program involves carbonizing the tissue samples on a hot plate and then ashing them in a muffle furnace at 500°C. A 20-mg aliquot of the ash is placed in a crater in a 1/4-in. pure spectrographic graphite electrode and burned in a 10-amp, d-c arc. Twenty different elements have been detected by this method. A more sensitive method that employs cathode layer techniques and a method for making quantitative estimates are under development.

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## PUBLICATIONS AND SPECIAL REPORTS

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4. A. H. Emmons and R. A. Lauderdale, "A Method for the Detection and Estimation of Low Levels of Radioactive Contaminants in Water," *Nucleonics* (in press).

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