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HEALTH PHYSICS DIVISION

QUARTERLY PROGRESS REPORT

FOR PERIOD ENDING OCTOBER 20, 1951

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HEALTH PHYSICS DIVISION

K. Z. Morgan, Director

QUARTERLY PROGRESS REPORT

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DATE ISSUED

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HEALTH PHYSICS DIVISION QUARTERLY PROGRESS REPORT

RADIOACTIVE WASTE DISPOSAL RESEARCH

R. J. Morton

The construction and installation of major equipment of the Health Physics Waste Research Building has been practically completed during this period, and this facility is to be occupied early in November 1951. According to present plans this new building will be used primarily to house laboratory and pilot-plant studies on water and liquid-waste decontamination processes and also for the location of other study projects that require relatively large space and apparatus or use of the controlled temperature rooms that are provided.

The cooperative program of research on radioactive waste problems by the U. S. Public Health Service and the Laboratory has been reorganized, as previously planned, to include increased participation by the Public Health Service. The Technical Advisory Board for Research on Radioactive Water Decontamination met in Washington, D.C., September 28, 1951, for further review and to make recommendations regarding this joint program.

Personnel changes have included the assignment of one additional sanitary engineer from the Public Health Service, assignment of a limnologist and two scientific aides by the Tennessee Valley Authority to complete the research staff of the Ecological Study of White Oak Creek, and completion of the assignment and stay at the Laboratory of the sanitary engineering research participant from North Carolina State College.

WATER AND LIQUID-WASTE DECONTAMINATION PROCESSES

T. W. Brockett, W. J. Lacy, A. G. Friend, D. A. Pecsok, W. A. Hoyt, O. R. Placak, C. P. Straub

Laboratory studies were made of the removals of tracer quantities of Ce^{137} and of Cd^{115} from water by using conventional water treatment processes. Adsorption of cesium on suspended clay particles resulted in substantial removals, whereas coagulation and sand filtration effected no further removals. Both adsorption by clay particles and coagulation were somewhat effective in removing cadmium, resulting in gross removals up to about 90%. Water-softening procedures gave essentially no removal of cesium, whereas cadmium was removed up to about 99% by excess lime-soda treatment. Both isotopes exhibited practically complete removal by filtration through columns containing either cationic exchange resins or granular burnt clay.

The removal of I^{131} from water by various procedures that have been adopted for fluoride removal in water supplies was attempted. Coprecipitation of iodide with excess lime-soda treatment and with magnesium oxide treatment proved ineffective. Filtration through bone-charcoal beds showed some removal and apparently the iodate ion rather than the iodide ion was preferentially removed. Further

studies with filter-column beds of Defluorite (a proprietary bone-char compound) are planned.

Aeration experiments using activated sewage sludge showed similar removals for cesium, cadmium, and iodine. Removals of from 60 to 80% were obtained following various periods of aeration, although the addition of carrier iodine to the I^{131} solution markedly lowered the removal.

The study of the removal of various radioisotopes from Oak Ridge tap water, by means of 14-mm columns containing a depth of 24 in. of ion-exchange resins, is the thesis research project of a graduate student (A. G. Friend, Virginia Polytechnic Institute). Tests conducted on the removal of carrier-free I^{131} in concentrations of 1.5×10^{-2} $\mu c/cc$ indicate that removals of about 99.4% can be expected with the use of a strongly basic anion-exchange resin operating on the hydroxyl cycle at a flow rate of 2.5 gal/min/ft^3 of resin. The pH of the effluent in these tests was approximately 11.0. By mixing an equivalent amount of a strongly acid cation-exchange resin on the hydrogen cycle with the anion resin, the removal was increased to 99.9% and the pH of the effluent was lowered to 7.2.

Lime-Soda Softening Process. A study of the lime-soda softening process in the removal of Sr^{90} from water is the thesis project of another graduate student (W. T. Hoyt, N.C. State College). Removal of up to 99.7% of the activity of $Sr^{90} + Y^{90}$ added to water has been obtained by the use of the excess lime-soda softening process in jar tests. The required lime-soda doses (no excess lime) effected removals of about 75% of the activity (all of that due to yttrium), with partial removal of the strontium activity. The effectiveness of removal of yttrium was indicated by the fact that after the lime-soda treatment the activity in the water increased as one would expect from the buildup of yttrium, and in about 10 days the activity had approximately doubled due to the growth of the yttrium. The excess-lime treatment consisted of the addition of lime as $CaCO_3$ with the required amount of soda ash to precipitate the calcium as the carbonate. The results for various excess doses were as follows:

EXCESS LIME (ppm)	ACTIVITY REMOVAL (%)
0	75.0
20	77.0
50	80.1
100	85.3
150	97.3
200	99.4
300	99.7

Adding strontium nitrate, $Sr(NO_3)_2$, as a carrier in the following amounts and enough soda ash to precipitate it as the carbonate gave removals of the $Sr^{90} + Y^{90}$ up to about 90%:

$Sr(NO_3)_2$ CARRIER (ppm)	ACTIVITY REMOVAL (%)
50	77.0
100	79.8
150	89.5

Studies of the effect of pH and mixing time on activity removal showed small increases in the removal of $Sr^{90} + Y^{90}$ with the increase of mixing up to 30 min and of pH up to 12.0, as shown below:

MIXING TIME (min)	ACTIVITY REMOVAL (%)
10	71.0
20	75.0
30	76.2
40	75.2
60	75.6

pH	ACTIVITY REMOVAL (%)
10.5	77.5
11.0	80.5
11.5	81.4
12.0	83.5

The addition of coagulant as an aid in the treatment process proved to have little effect on Sr^{90} + Y^{90} activity removal. For the required lime-soda doses alum, sodium aluminate, and ferric chloride increased removals only about 1%. Trisodium phosphate and sodium silicate showed increased removals of about 3%. For excess lime-soda doses the silicate treatment had less than 1% effect on activity removal, but it greatly improved the settleability of the fine floc that forms at high excess doses.

Throughout this period, active work has continued on the special project concerned with the evaluation of the equipment and processes for the emergency treatment of water supplies.

SURVEY STUDIES AND ECOLOGICAL STUDY OF WHITE OAK CREEK DRAINAGE SYSTEM

M. J. Cook
J. M. Garner
V. I. Knobf
O. W. Kochtitzky
L. A. Krumholtz
R. A. Lauderdale
W. T. Miller
F. R. Nease
O. R. Placak

Controlled fish experiments in the laboratory were begun for the purpose of verifying and explaining the data obtained in the ecological study of White Oak Lake. A factorial experiment, designed to evaluate the significance of numerous factors simultaneously, was planned and outlined by a member of the ORNL Mathematics Panel. The plan of the experiment is to vary four factors (water spiking, food, food spiking, and time of removal) at three temperature levels as fish are exposed in water spiked at three different levels with radioisotopes and distributed in fruit jars. In the first of these exposures *Gambusia afinis afinis* weighing 0.3 to 1 g, was used. Ce^{137} was used as the test radioactive material, because this isotope has been determined to be of importance in the studies of fish under natural conditions in the White Oak Lake system.

A survey was made of the intensity of radiation from bottom deposits in the river and lakes below White Oak Creek by means of a "flounder," a water- and sediment-scanning instrument. The survey extended for a distance of approximately 200 miles downstream from White Oak Lake in the Clinch and Tennessee Rivers. In the near future, additional background data will be obtained to aid in the interpretation of the survey results. A preliminary review indicates slight elevations above background radioactivity in the bottom sediments throughout the 200 miles, except where water velocities have scoured the bottom clean.

A rotating cup-type liquid counter[1] for measuring the level of radioactivity in river samples was obtained from the Health Physics Instrument Development Section. The sensitivity of this instrument (10^{-6} $\mu c/cc$ of beta activity) is expected to permit measurements at a level of 10^{-7} $\mu c/cc$ in water when the samples are concentrated by evaporation to one-tenth of the initial volume. It is planned to run samples concurrently by several assay techniques in order to determine the least time-consuming procedure that is satisfactory. The purpose is to facilitate the procurement of more numerous and more accurate data from water sampling surveys. Because of fluctuations in the background of the

(1) *Health Physics Division Quarterly Report for Period Ending July 20, 1951*, ORNL-1086.

counter in its present location, considerable difficulty has been experienced at the extremely low levels being counted.

Routine logging of the 51 test wells is to be resumed after the two additional probe and cable reel assemblies have been completed. Through the use of an ion-exchange column detector (description to follow) gross beta determinations were made on 5-gal samples of water from each of five selected test wells that had shown higher than the average level of radioactivity during well-logging observations. The highest level of activity found in any of the water from these five wells was 8.5×10^{-7} $\mu c/cc$. By the same method of gross beta analysis the level of natural background activity in an uncontaminated spring in the White Oak Creek area upstream from the Laboratory was found to be 2.5×10^{-7} $\mu c/cc$.

Ecological Study of White Oak Creek. Progress of the study during the period by the ecological staff with cooperation from the Laboratory and from other units of the Tennessee Valley Authority has included the following:

1. A determination of the time of water travel under stratified conditions in White Oak Lake was completed. the time of travel of the fastest moving water through the lake to the dam was about the same as found in previous determinations.

The collection and analysis at ORNL of routine biweekly water samples from White Oak Creek and White Oak Lake have been assumed by the ecological staff because of the transfer from Knoxville to Chattanooga of the TVA laboratory that formerly did the work.

2. The population of *Gambusia afinis afinis* planted in the settling basin during the spring was destroyed, apparently by some toxic chemical waste. Another planting was made September 18 and it appears to be thriving. It is intended that specimens will be collected for detailed examination after a period of exposure.

Weekly collections, dissections, and radioassays of three bluegill and three crappie from the lake are being made, because the analyses of fish from White Oak Lake have given some indication of great differences of strontium content in the bone during winter as compared with summer periods. It is planned to continue this routine through enough seasons to determine whether environmental changes, such as temperature, affect the rate of uptake and of elimination of radioactivity from the various fish tissues. The details of radiochemical analyses of the fish tissues have been worked out with the Analytical Chemistry Division, which is making these analyses.

During September a second five-weeks' fall study of fish population was initiated.

3. In the botanical studies, specimens for addition to the herbarium and for radioassay have been collected and the vegetation of the area is now well represented.

The survey was completed of the prominent vegetation species in study plots around White Oak Lake and on White Oak Creek up to Haw Gap Bridge. Samples for gross beta assay, totaling about 2000, were taken from every important species of plant occurring around White Oak Lake.

4. Limnological studies, which have lagged behind work on the physical and chemical, fisheries, biological, and botanical phases of the study, are being accelerated since the limnologist reported for duty on October 1.

INSTRUMENTATION AND TECHNIQUES

J. M. Garner R. A. Lauderdale

Developmental work on a column-type of water monitor for use in the detection of low levels of activity is nearing completion and a report on this instrument is being prepared. The unit, which consist chiefly of a 10-in., thin-walled (30 mg/cm^2), glass GM-tube surrounded by a bed of Dowex-50 cation-exchange resin, operates by concentrating the radioactive elements from large volumes of water passed through the bed. The buildup of activity in the resin bed is recorded on a strip chart as a line of constant slope for each concentration of activity. The slope of the line is therefore a measure of the concentration of activity in the water.

This water monitor unit was calibrated by the use of tap water spiked with different concentrations of an aged, mixed fission-product solution having an average β energy of about 0.7 Mev. From the data obtained, it has been calculated that activities as low as 10^{-9} μc/cc of mixed fission-product activity can be detected by passing 40 gal of water through the unit. By plotting the known activity of the feed as a function of the slope of the recorded line in counts per minute per liter a straight line was obtained that may be represented by an equation of the type

$$\mu\text{c/cc in feed} = \frac{1}{K} \times \text{recorded c/m/liter},$$

where K is essentially a counting efficiency correction that will depend on the dimensions of the detector assembly and on the energy and type of radiation.

THEORECTICAL PHYSICS

J. Neufeld W. S. Snyder

FAST-NEUTRON TOLERANCE CALCULATIONS

Collision densities and energy losses of a monoenergetic beam of neutrons normally incident on an infinite slab of tissue of 30 cm thickness have been obtained with the assistance of members of the ORNL Mathematics Panel by means of a Monte Carlo procedure. Table 1 summarizes the results to date:

TABLE 1
Collision Densities and Energy Losses of a Monoenergetic Beam

ENERGY OF NEUTRONS	10 Mev	5 Mev	2.5 Mev	0.5 Mev
Maximum energy absorption at surface (ergs/cm^3/neutron)	6.43×10^{-7}	7.16×10^{-7}	4.75×10^{-7}	1.91×10^{-7}
Per cent of energy loss due to hydrogen scattering	83.3	89.6	93.0	92.2
Maximum dose at surface (rep/cm^3/neutron)	8.10×10^{-8}	8.03×10^{-8}	5.32×10^{-8}	2.21×10^{-8}
Maximum permissible flux (neutrons/cm^2/sec) based on 40 hr/wk	25.7	25.9	39.2	94.3
Per cent of neutrons thermalizing in a 30-cm slab	50.3	63.4	71.1	65.8

In all cases the maximum absorption of energy occurs at the surface. The maximum dosage figure is calculated by using a relative biological effectiveness of 10 for energy losses due to protons and a relative biological effectiveness of 20 for heavier tissue ions (carbon, oxygen, nitrogen). It is assumed that 93 ergs/cm^3 is the equivalent of the roentgen. Calculations for the resulting thermal doses are under way.

STOPPING POWER OF PROTONS, ALPHA PARTICLES, AND IONS OF CARBON AND OXYGEN IN TISSUE

The stopping cross sections have been computed by using the results of Hirschfelder and Magee[1] and Knipp and Teller.[2] These values are tabulated for comparison with those obtained by use of the method described in ORNL-884.[3] The lateral energy distribution (width of track) is being computed.

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[1] J. O. Hirschfelder and J. L. Magee, "Range-Energy Relations for Protons in Substances Containing C, H, O, A, and Xe," *Phys. Rev.* **73**, 207 (1948).

[2] J. Knipp and E. Teller, "On the Energy Loss of Heavy Ions," *Phys. Rev.* **59**, 65, 659 (1941).

[3] J. Neufeld, "Ionization and Excitation Losses of Charged Particles of Intermediate Energies," ORNL-884 (Dec. 14, 1950).

PHYSICS OF NUCLEAR RADIATIONS

H. K. Richards

FAST-NEUTRON POCKET-METER INVESTIGATION

J. S. Cheka

The possibility of an ionization current caused by carbon-recoil atoms in a graphite-lined chamber exposed to fast neutrons was mentioned in a previous report. In order to evaluate this possible recoil-atom effect, a beryllium- and an iron-lined chamber were made to the same dimensions. These dimensions were: inside diameter, 1.76 cm; length, 9.25 cm; and electrode diameter, 1.12 cm. Beryllium should increase such a recoil ion effect and iron should eliminate it.

Several gas fillings were also tried by the use of a plenum chamber. Exposures were made to Co^{60} γ and to neutrons (and associated gamma radiation) from a Po-B and Po-Be source. In the tables following, all gas pressures are corrected to 760 mm Hg, and corrections are made for the capacitance differences of the three chambers. Table 2 shows response to Co^{60} γ radiation. The figures in Table 2 show discharge in divisions per minute on a minometer scale at a fixed geometry and are valid for comparison only.

TABLE 2

Ionization-Current Response of Chambers To Gamma Rays from Co^{60}

GAS	CHAMBER WALL		
	Be	C (Graphite)	Fe
Air	31.6	31.2	35.0
CH_4	29.5	31.4	34.5
He	6.3	6.1	6.8
H_2	5.3	5.3	5.8

Table 3 shows response of these chambers to Po-B neutrons. Again the figures indicate divisions per minute at a fixed geometry, corrected to 760 mm Hg pressure. The table is self-consistent, but responses are not evaluated in terms of neutron flux.

TABLE 3

Ionization-Current Response of Chambers to Neutrons (and associated gamma rays) from Po-B

GAS	CHAMBER WALL		
	Be	C (graphite)	Fe
Air	1.96	1.45	1.58
CH_4	2.06	1.65	1.80
He	0.72	0.59	0.56
H_2	0.62	0.43	0.42

Table 4 shows response to polonium-beryllium neutrons on the same basis as given in Table 3.

TABLE 4

Ionization-Current Response of Chambers to Neutrons (and associated gamma rays) from Po-Be

GAS	CHAMBER WALL		
	Be	C (graphite)	Fe
Air	3.82	2.99	3.13
He	0.95	0.76	0.81

Some tentative results are indicated from these tables, assuming that response to the gamma component of the neutron sources follows a pattern somewhat similar to response

to Co^{60} γ. (1) Ionic current in the Fe chamber is about 11% greater than in the C chamber for the Co^{60} γ radiation. (2) The carbon-atom current, if present, is small, being about 3% with the Po-B source and 7% with the Po-Be source in the C-air chamber; however, this is the order of the probable error of the data. (3) About 40% of the current in the Be-air chamber originates from the Be recoils and the $Be^9(n,\alpha)He^6$ reaction for both Po-B and Po-Be sources. (4) The current caused by proton recoils is about 13% of the total current in the Be-CH_4, C-CH_4, and Fe-CH_4 chambers with the Po-B source. (5) The current caused by the He recoils is about 50% of the total current for the Po-B source and about 25% of the total current for the Po-Be source in the Be-He, C-He, and Fe-He chambers. (6) The current due to the proton recoils is about 40% of the total current in the Be-H_2, C-H_2, and Fe-H_2 chambers for the Po-B source.

It must be noted that these are relative figures, and the use of a light gas filling reduces total current, e.g., the use of He, instead of air, reduces sensitivity to Co^{60} γ by a factor of 5 and the response to Po-B neutrons and associated gamma rays by a factor of 3.

By the use of the same geometry with the Co^{60} γ source, the interposition of a 1-in. Bi shield decreased the ionization current by a factor of 3.1 and a 2-in. Bi shield decreased it by a factor of 10.9 in all three chambers when filled with air, and within a few per cent of these values when filled with He.

In the case of the neutron sources the attenuation with 1-in. of Bi was variable with the different gases and was much less than for Co^{60} gamma rays. With air it was about 1.6 for the Po-B source, and about 1.8 for the Po-Be source. The Fe wall has been replaced by a polyethylene wall and new tests are under way.

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

R. D. Birkhoff

Experiments have been concluded on the absorption of the internal conversion electrons from Ba^{137} in various thicknesses of materials of several atomic numbers. Some of the results of the experiments are indicated in Figs. 1 and 2. Excellent agreement with the Bethe-Bloch theory for the average rate of energy loss is obtained over the range of the periodic table. In addition, the most probable rate of energy loss calculated from the Landau theory appears to be verified by our results. The width at half maximum (see Fig. 3) of the observed straggling curves, however, is about 2.5 times as large as predicted from the Landau paper.

An attempt will be made to calculate the beta dose at various distances below the surface of an irradiated slab by the use of the data previously given and an absorption curve obtained from the areas of the straggling distributions for various foil thicknesses.

MEASUREMENT OF RADIATION BY FREQUENCY VARIATION OF AN R-F OSCILLATOR

H. K. Richards

The experiments to measure ionizing radiation by frequency variation were continued. A 29-cycles/min frequency

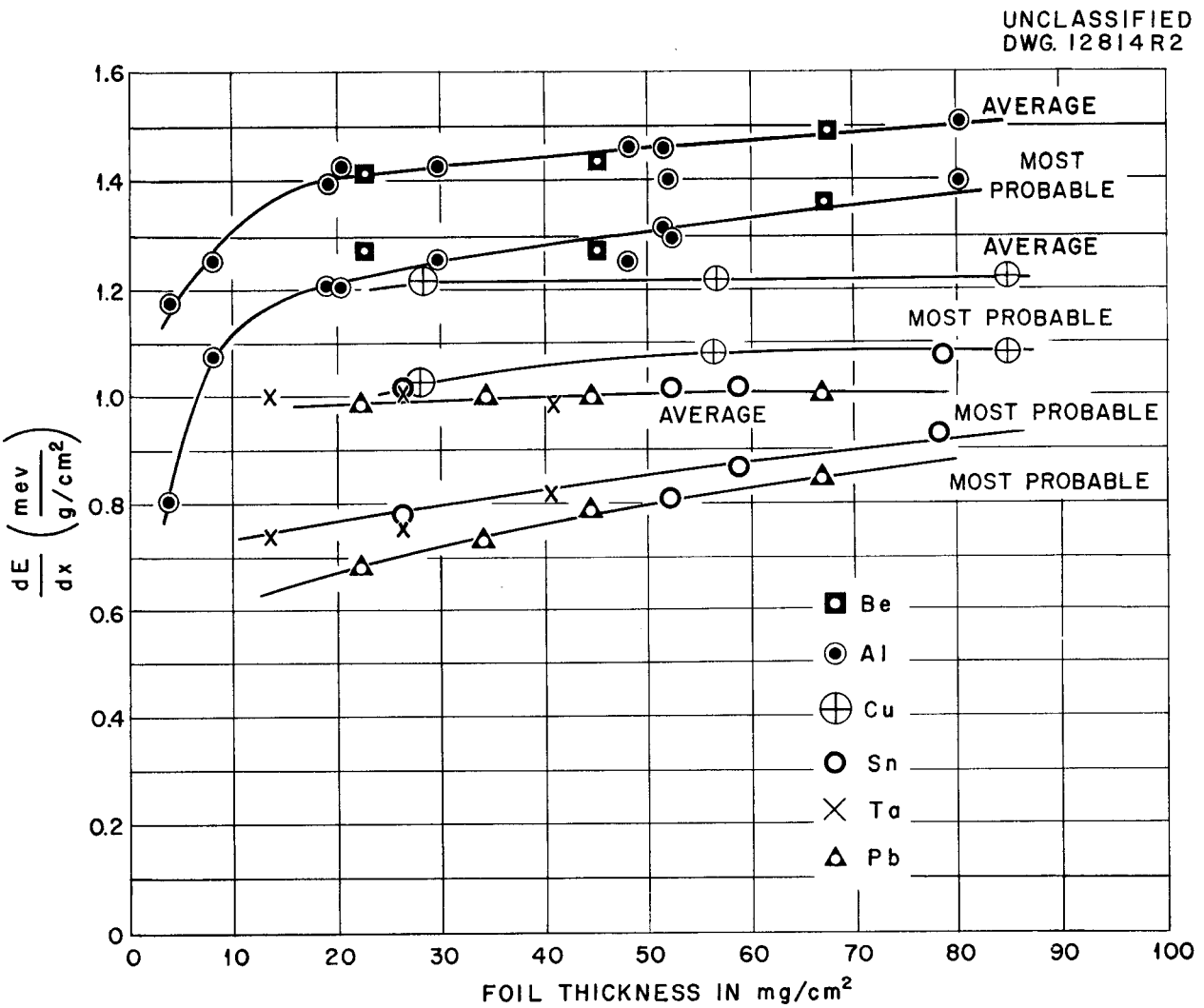

Fig. 1. Most Probable and Average Rate of Energy Loss at 626 kev vs. Foil Thickness.

shift was produced with 1.37 mr/hr of Ra gamma rays.

A new construction in progress will replace the steel-wire suspension of the variable-capacitance-producing leaf by a quartz fiber to provide a better reproduction and stability of the system.

RANGE MEASUREMENTS OF BETA PARTICLES

T. E. Bortner

Work of the past quarter is being continued on the measurement of the range of beta particles in absorbers of various atomic numbers. These measurements are being accomplished by using a standard thin-window beta counter with necessary corrections being made. Parallel experimental range measurements are also being made by using a windowless counter.

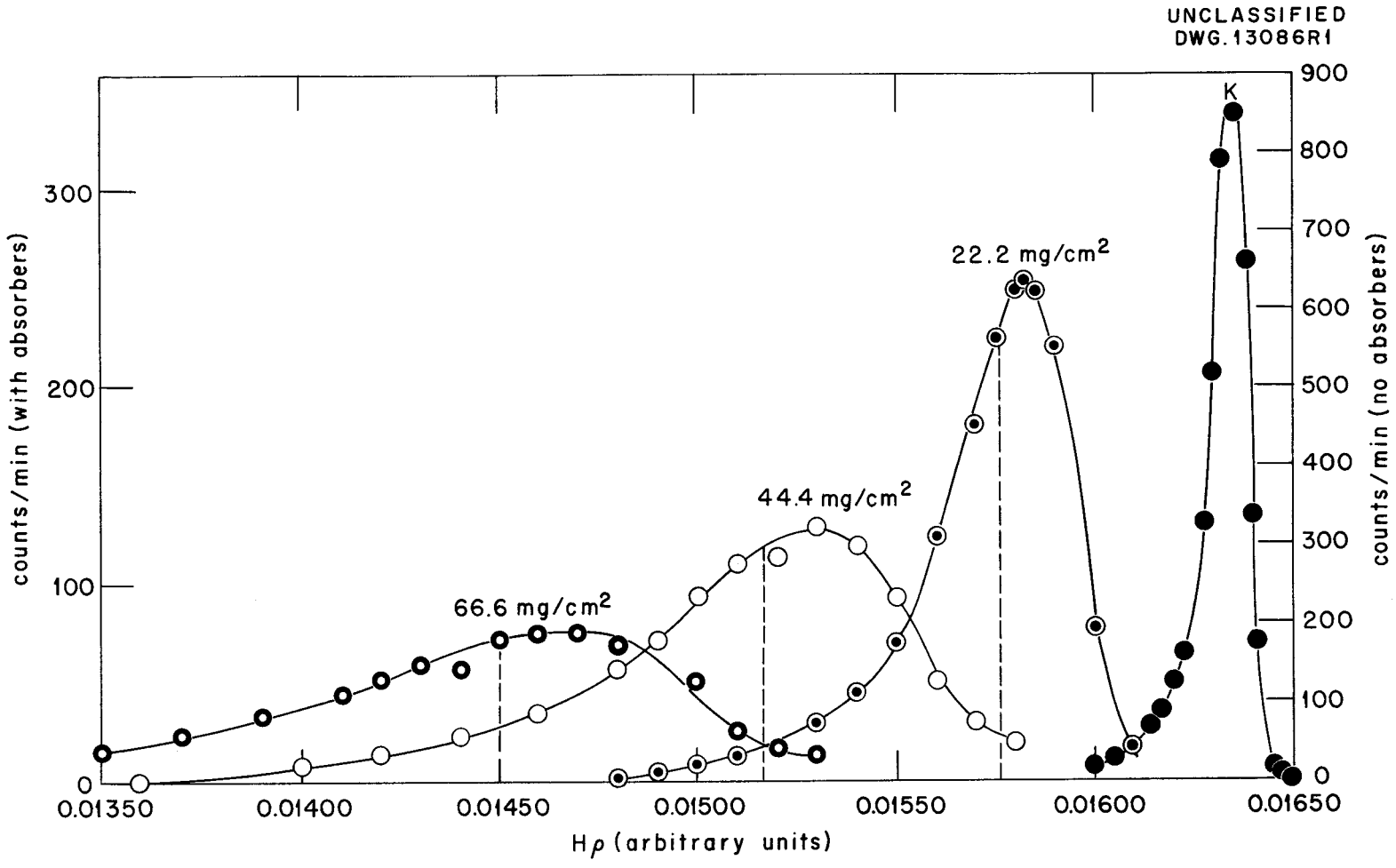

Fig. 2. Straggling of K-Conversion Electrons from Barium^{137} in Beryllium.

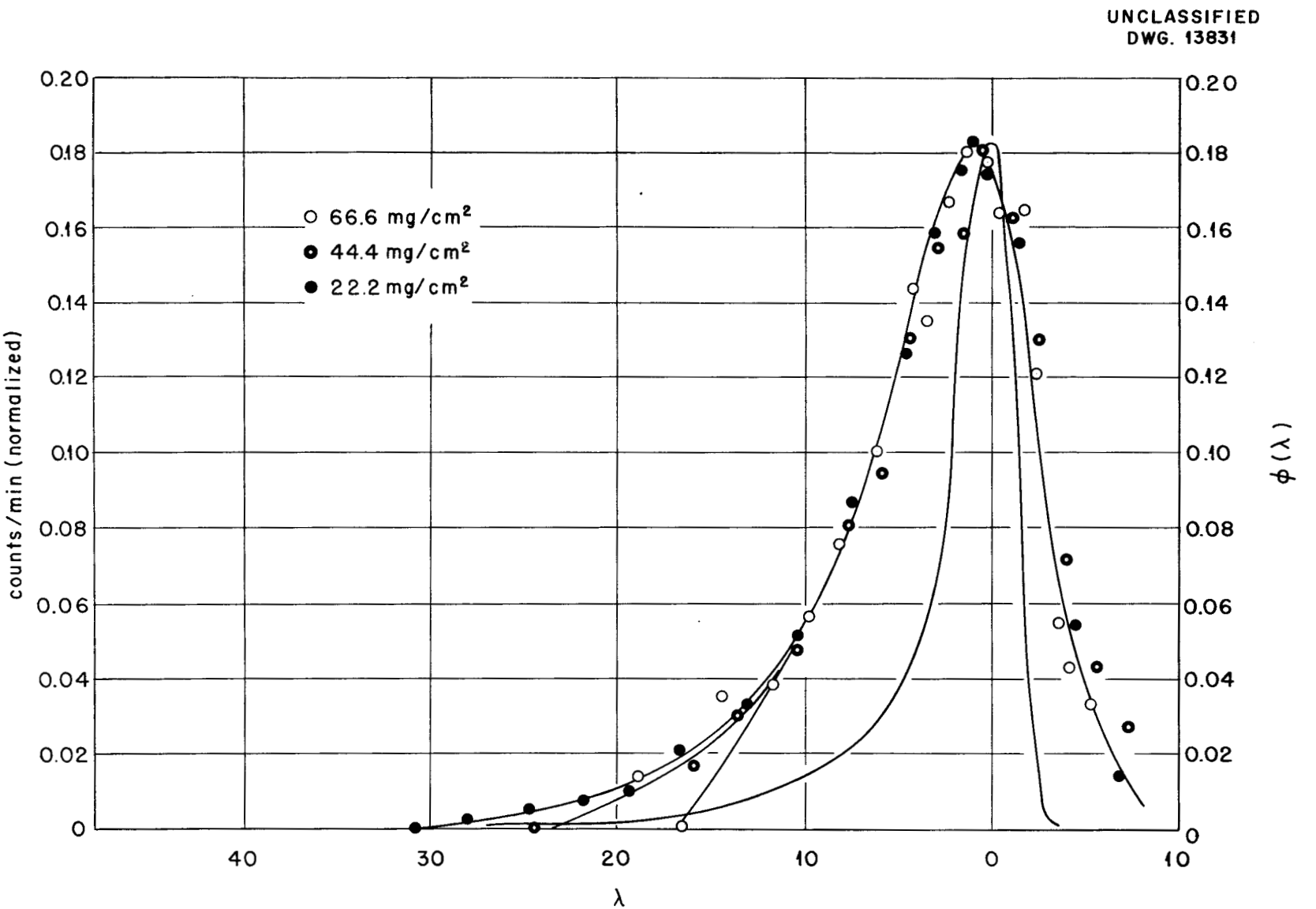

Fig. 3. Beta Straggling Distributions vs. Landau's λ Function (Beryllium Absorber)

RADIOCHEMICAL ANALYSIS

L. B. Farabee

ANALYSIS FOR PLUTONIUM ON AIR FILTERS

The technique for quantitative determination of plutonium on constant-air-monitoring filters by direct counting of the alpha is unreliable owing to: (1) indeterminate self-absorption on the filter and (2) the presence of large amounts of other alpha-emitting isotopes. It was expedient to develop procedures of analysis for plutonium on two types of filters presently used at Oak Ridge National Laboratory. Such procedures could be used specifically for two purposes: (1) to detect plutonium present in particulate matter that is filtered from the air in the Oak Ridge National Laboratory area and (2) to determine the extent of the expulsion of plutonium through hood ducts that open directly into the air.

The asbestos base filter was reduced to soluble compounds by burning the cellulose in the flame of a Meker burner and dissociating the remaining silicates by perchloric acid and hydrofluoric acid. For the Whatman filter No. 41, wet oxidation by the use of nitric acid and perchloric acid was found satisfactory and easy to carry out. Conventional procedures were then employed to separate plutonium from the inorganic constitutents of the filters.

PHYSICS OF RADIATION DOSIMETRY

H. H. Hubbell

CALIBRATION OF X-RAY MACHINE

The dose-rate calibration of the 250-kv x-ray machine has been continued for a variety of currents, voltages, and filtrations.

FAST-NEUTRON DOSIMETER

Further design and testing work has been done on the fast-neutron survey dosimeter preparatory to commercial production of the instrument.

DISTRIBUTION OF FLUX IN X-10 GRAPHITE PILE

The experiment on the space distribution of neutron flux in the X-10 graphite pile has been improved and repeated with the cooperation of the School of Reactor Technology laboratory personnel. The curves obtained show plainly the general trend of the flux falling off from center to edge of the pile and, in addition, a small ripple owing to absorption of thermal neutrons by uranium slugs and a large depression in flux due to a control rod. A report will be issued on this project.

THERMAL-NEUTRON SURVEY INSTRUMENT

G. S. Hurst

A report[1] describing a thermal-neutron survey instrument will be issued in the near future. The report contains a complete description of the electronic circuit as well as the drawings necessary to reproduce the proportional-counter detector.

[1] G. S. Hurst, D. J. Knowles, and Catherine Yochem, "A Neutron Survey Instrument," ORNL-1134 (Jan. 2, 1952).

PROPORTIONAL-COUNTER DEVELOPMENT

G. S. Hurst

The equations describing the shape of a proportional-counter pulse for the case of an extended track of ionization have been derived. Secondly, the equations giving the shape of the pulse after being amplified by an amplifier have been developed. Numerical work is being done by the Mathematics Panel so that one may know the conditions under which the pulse height after amplification is proportional to the number of ion pairs producing the pulse, independent of the orientation of the track.

PULSE-HEIGHT INTEGRATOR

G. S. Hurst

A method of weighting pulses by their height has been developed in cooperation with the Instrument Department. The instrument will be described completely in a forthcoming report.

PHYSICAL CALCULATIONS

R. H. Ritchie

Further calculations for the determination of the diffusion length in the sigma pile have been initiated with the cooperation of the Mathematics Panel.

Some work has been done on a theory of multiple scattering of electrons in foils, which includes both energy and angular distribution of electrons as a function of depth in the foil.

Efficiency calculations have been carried out for a cylindrical scintillation counter and a particular source geometry. This work will appear in a forthcoming memorandum.

EDUCATION AND TRAINING

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

AEC FELLOWSHIP PROGRAM

The 1950-51 group of 20 AEC Fellows completed field training on August 31. Four of the Fellows applied for and received an extension of the fellowship and now are doing research work for completion of their Master's degrees. Arthur Smith and Charles Wright elected to return to Vanderbilt University. Luis Garcia and Ford Kalil remained at the Laboratory. The 1951-52 group of 20 Fellows registered at Vanderbilt University September 24.

TRAINING PROGRAM FOR MILITARY PERSONNEL

The 21 NME officers and the two from the Army Chemical Center completed their training period on August 17. Captain H. W. Curtis, West Point, remained until September 1.

TRAINING PROGRAM FOR AEC CONTRACTOR PERSONNEL

During this quarter the Education and Training Section has been responsible for the training of one health physicist for Dow Chemical Company, eight American Cyanamid Company personnel, and six personnel for the DuPont Company.

MISCELLANEOUS ACTIVITIES

One member of the staff began teaching a course in Nuclear Physics on September 17, in the Staff Educational Program for the Reactor School. Another member of the staff has been working full time on samples in connection with the Nevada Testing Program. Classes for the Apprentice Training School began during this period.

EXPERIMENTAL RADIATION MEASUREMENTS

F. J. Davis

AIRPLANE MEASUREMENTS

F. J. Davis P. W. Reinhardt

A series of flights over sources of Na^{24}, Co^{60}, Cs^{137}, Ra, and Ta^{182} were made at heights from a few hundred feet to, in some cases, more than 3000 feet. The variation of gamma-ray response of the NaI-crystal scintillometers indicated a buildup factor roughly proportional to the altitude. A more exact representation would be a quadratic, such as $1 + ah + bh^2$ or $1 + ah^b$, where a and b are constants, depending on the energy of the primary radiation, and h is the height. For the purpose of altitude compensation of aerial radiation measurements of radiation coming from the ground, a buildup factor proportional to the height is good enough. A project measuring the absorption of gamma rays in water and other media to obtain a more exact relation for buildup factors and their dependence on energy is being contemplated.

Assuming a buildup factor proportional to height and integrating over a uniformly distributed source in the ground, one obtains the simple relation that the attenuation is proportional to $e^{-\mu h}$, where μ is the the absorption coefficient for air. A few flights were made to check this relation by flying first over water and then over land at various altitudes, by using the natural radioactivity of the ground for a plane distributed source. The data obtained fit the theoretical relation within experimental error.

A curve of the variation of the background vs. altitude was obtained by making a series of flights over the Pacific Ocean. The curve shows little change in background for altitudes up to about 8000 feet and then and increase with altitude to a background at 15,000 feet about double that at low altitudes.

RADON MEASUREMENTS

W. C. King L. F. Garcia

Three samples of dolomite rock were obtained from one of the oil wells in the Panhandle gas field in Texas. The radon emanation from the samples was measured in order to determine whether the radon escaping from the wells could be accounted for by the natural activity in the dolomite. The three samples, for which the radium and radon values are given in Table 5 were described as:

Sample A - finely porous, strong oil odor, porosity probably more than 10%;

Sample B - less porous than A, faint oil odor;

Sample C - dense, only slightly porous, oil odor.

It is not surprising to have less emanation from the powder than the rock, since radon adsorbs readily on many surfaces.

Two additional problems that have been undertaken by trainees assigned to this section are (1) the study of the variation of the radon and radium content of the Clinch River and (2) a study of the radon variation in the air.

TABLE 5

Radium and Radon Values

SAMPLE	RADIUM CONTENT ($g/g \times 10^{-12}$)	RADON EMANATION FROM ROCK, 130 g ($curies/g \times 10^{-12}$)	ROCK EMANATION FROM ROCK POWDER, 100-MESH ($curies/g \times 10^{-12}$)
A	0.294	0.0311	
	0.286	0.0310	0.0315
B	1.32	0.1135	
	1.28	0.1142	0.101
C	0.202	0.0159	
	0.199	0.0157	0.0134

DRILL-HOLE MEASUREMENTS

J. A. Harter

A NaI-scintillation probe and enriched-BF_3 neutron counters were tested at Grand Junction, Colorado, for possible application in logging of carnotite deposits. Five simulated drill holes, with ore layers of known quantity and assay, were logged. The 1 11/16-in.-OD scintillation probe (using a 1 1/2-in.-diameter by 1-in. sodium iodide crystal and a C7151 photomultiplier tube) was used both as a high-efficiency detector and as a spectrometer to measure the carnotite gamma-energy spectrum as a function of sand-absorber thickness. The maximum counting rate at the center of a 4-ft diameter, 20-in.-thick layer of 4.25% ore was in excess of 6 million cpm, compared to a background of 4500 cpm. Quite accurate determination of the ore-layer thickness was possible for strata measurement. Some shift in energy spectrum was observed; the data is being further analyzed. The neutron-counter characteristics drifted so badly between manufacture and test that they could not be used; this drift is attributed to BF_3-gas impurities. The counters are being refilled for further tests.

PERMISSIBLE INTERNAL DOSE - RADIOISOTOPES

K. Z. Morgan M. R. Ford
M. J. Cook

RADIOISOTOPES - MAXIMUM PERMISSIBLE CONCENTRATIONS

Preliminary calculations of maximum permissible concentrations of radioisotopes in total body, in air, and in water have been made for 35 additional isotopes, largely fission products.

The complete list of isotopes on which preliminary calculations have been made up to October 1 follows.

Common radioisotopes that are alpha emitters: U-natural (soluble and insoluble), U^{233} (soluble and insoluble), Ra^{226}, Rn^{222}, Pu^{239} (soluble and insoluble), Po^{210} (soluble and insoluble).

Radioisotopes of common body elements: C^{14}, H^{3}, Ca^{45}, P^{32}, K^{42}, S^{35}, Na^{24}, Cl^{36}, Fe^{55}, Fe^{59}, Mn^{56}, Cu^{64}, I^{131}.

Other radioisotopes of current interest: Sr^{89}, $Sr^{90} + Y^{90}$, A^{41}, Xe^{133}, Xe^{135}, Co^{60}, Au^{198}, Au^{199}, Cr^{51}, Ni^{59}, Mo^{99}, Th^{234}, As^{76}, Ga^{72}, $Ba^{140} + La^{140}$, F^{18}, Be^{7}, Sc^{46}, V^{48}, Ge^{71}, Rb^{86}, Y^{91}, Nb^{95}, Tc^{96}, $Ru^{106} - Rh^{106}$, Rh^{105}, Pd^{103}, $Cd^{109} - Ag^{109m}$, Sn^{113}, Te^{127}, Te^{129}, $Cs^{137} - Ba^{137m}$, La^{140}, Re^{183}, Ir^{190}, Ir^{192}, Pb^{203}, At^{211}, Am^{241}, Cm^{242}, $Ce^{144} - Pr^{144}$, Pr^{143}, Pm^{147}, Sm^{151}, Eu^{154}, Ho^{166}, Tm^{170}, Lu^{177}, Ag^{111}, Ag^{105}.

Further biological studies of these and other isotopes are needed, especially under conditions of chronic ingestion and inhalation.

A re-examination of the maximum permissible concentration (mpc) of radon in air indicates that 10^{-8} $\mu c/cc$ (10^{-11} $\mu c/l$) of radon in air is probably a reasonable and acceptable mpc. If the air is well ventilated and free of dust, it would seem reasonable to increase the mpc of radon in air to 2×10^{-8} $\mu c/cc$ or perhaps to 10^{-7} $\mu c/cc$.

UNIVERSITY OF TENNESSEE RESEARCH AND DEVELOPMENT SUBCONTRACT

I. H. Tipton

The spectrographic laboratory at the University of Tennessee is in operation making a preliminary qualitative survey of trace elements in human heart, liver, kidney, bone, and skeletal muscle. A quantitative analysis of these tissues and others is to begin by December 1.

CONSULTATION AND SPECIAL PROBLEMS

OPEN-AIR MEASUREMENTS OF A 300-CURIE COBALT SOURCE

H. A. McAlduff

In cooperation with the Medical Division of the Oak Ridge Institute of Nuclear Studies, open-air measurements were made of a large 300-curie cobalt source to be used for cancer therapy. Preliminary examination of the data confirms the fact that determination of the source strength of large sources by open-air measurements is grossly inaccurate due to limited information concerning the buildup factor introduced by air- and ground-scattering. A report of the data obtained will be forthcoming in the near future.

PUBLICATIONS AND SPECIAL REPORTS

PUBLICATIONS

1. C. P. Straub, R. J. Morton, and O. R. Placak, "Oak Ridge Reports Results on Water Decomtamination Study," *Eng, News-Record* **147**, 7, 38-41 (Aug. 16, 1951).

2. R. A. Lauderdale, "Treatment of Radioactive Water by Phosphate Precipitation," *J. Ind. Eng. Chem.* **43**, 1538-1541 (July 1951).

3. F. J. Davis, "Fall-Out in Southeastern U.S. During January and February 1951, from Nevada Atomic Tests," ORNL-1081 (Nov. 8, 1951).

4. C. P. Straub, R. J. Morton, and O. R. Placak, "Studies on the Removal of Radioactive Contaminants from Water," *J. of Amer. Water Works Assoc.* **43**, (Oct. 1951).

5. D. M. Davis, F. J. Davis, "Air Activity Studies Conducted at Corryton, Tennessee, and Gainsville, Florida," ORNL CF 51-9-63 (Oct. 25, 1951).

6. R. J. Morton, "Water Decontamination," Part of Panel Discussion on Engineering Aspects of Atomic Energy, 1951, *Conference of State Sanitary Engineers*, Washington, D.C., May 9, 1951.

7. R. J. Morton, "Environmental Problems of Radioactive Waste Materials," lecture presented on September 4, 1951, at *Third Annual Oak Ridge Summer Symposium*, TID-5031, The Role of Engineering in Nuclear Energy Development (December, 1951).

8. K. Z. Morgan, "Standards of Radiological Protection and Control," lecture presented on August 30, 1951, at *Third Annual Oak Ridge Summer Symposium*, TID-5031, The Role of Engineering in Nuclear Energy Development (December, 1951).

SPECIAL REPORTS

(Copies available upon request)

1. O. R. Placak, "Disposal of C^{14} Wastes," a section in the tentative report and recommendations being prepared by the Subcommittee on Waste Disposal and Decontamination of the *National Committee on Radiation Protection.*

2. C. P. Straub, "Radioactive Materials and Environmental Health," paper presented at the *Twentieth Annual Georgia Water and Sewage School*, Georgia School of Technology, Atlanta, Georgia (Sept. 21, 1951).

3. C. P. Straub, "Effects of Radioactivity on Water Supplies," paper presented at the *Joint Annual Meeting of the Missouri Section of the American Water Works Association and the Missouri Water and Sewage Conference*, St. Joseph, Missouri (Oct. 2, 1951).

4. C. P. Straub, "Effect of Radioactive Materials on Water Supplies," paper presented at the *Fortieth Annual Convention of the Southwest Section of the American Water Works Association*, Fort Work, Texas (Oct.. 15, 1951).

5. K. Z. Morgan, "Maximum Permissible Concentration of Radon in the Air," prepared for *Subcommittee on Internal Dose of the National Committee on Radiation Protection* (Oct. 4, 1951).