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QUARTERLY PROGRESS REPORT

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HEALTH PHYSICS DIVISION

K. Z. Morgan, Director

QUARTERLY PROGRESS REPORT

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[redacted] QUARTER ENDING JULY 20, 1951

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INSTRUMENT DEVELOPMENT

CONSTANT-FLOW WATER MONITOR

The apparatus reported in ORNL-1004 has been extended in sensitivity to include the detection of alpha and soft beta radiation by using a 20-kev beta-sensitive Geiger counter having a beta window of 0.7 milligram per square centimeter, a window area of about 4.5 square inches, and a background counting rate of 12 counts per minute. The thin-wall counter is described in detail in ORNL Drawing No. D-9638. Sulfur^{35} in solution is detected at a level of 1.5×10^{-4} microcuries per cubic centimeter (maximum permissible concentration of sulfur^{35} in drinking water is 5×10^{-3} microcuries per cubic centimeter). A unique feature of this thin-wall counter is the resilience of the wall material. In spite of the thin and fragile pliofilm wall, it can be crushed out of shape but immediately blown back into shape.

Where the monitored water contains high-energy beta emitters (or mixed fission products), commercially available G. M. tubes having a shell mass of 30 milligrams per square centimeter are feasible. For example, a six-month-old solution of mixed fission products is detected by the RCL Mark 1 model 11 G. M. tube with an efficiency 80 per cent of that of the 20-kev thin-wall counter mentioned above.

BATCH-WISE LIQUID MONITOR

The instrument developed for the purpose of calibrating the continuous-flow water monitor can also be used for the measurement (batch-wise samples of 80 cubic centimeters or less) of radioactive liquids. This instrument is described in ORNL Drawings Nos. D-9047, D-9048, D-9049, D-9050, C-9203, and D-9638, and comprises a motor-driven flanged cup to hold 80 cubic centimeters of a liquid sample, the 20-kev beta sensitive Geiger counter mentioned above, and lead shielding. Rotation of the flanged cup at 1800 revolutions per minute produces a cylindrical void in the liquid sample into which the beta counter is lowered. The beta counter is essentially surrounded but not touched or contaminated by the sample solution. Various radioactive isotopes are being procured for the purpose of repeating the energy-dependence calibration with greater accuracy.

The sensitivity of the instrument is sufficient to measure the normal radioactivity (K^{40}) in human body fluid. For example, where the background counting rate was 10 counts per minute, 80-cubic-centimeter samples of urine measured a net counting rate of about 10 counts per minute.

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RADIOACTIVE-WASTE-DISPOSAL RESEARCH

DURING this period, the facilities and activities for research on radioactive-waste-disposal problems have been continued without major changes. A temporary building was moved to a site east of the settling basin and equipped to provide additional work space for newly assigned personnel. A large wooden tank of approximately 35,000 gallons capacity, was moved and erected on the same site. Personnel added to the group for temporary periods or work on special projects have included one sanitary engineer research participant, two sanitary engineers for work on M. S. thesis problems, and a radiochemist assigned from the U. S. Corps of Engineers.

WATER AND LIQUID WASTE DECONTAMINATION PROCESSES

Detailed studies of conventional and modified water-treatment processes have been continued on a laboratory and also a small pilot-plant scale. The effect of acid (HCl) or salt (NaCl) on the adsorptive capacity of a variety of adsorbents was investigated. The acid and salt were used in pretreatment of the adsorbent materials. No appreciable effect was apparent.

Studies were begun on a series of fission products to determine the effect of turbidity (added clay slurry) and standardized coagulation in the removal of these materials from water. Experiments with cesium^{137} were completed in which coagulation was accomplished by dosages of 1.0 grain per gallon each of calcium hydroxide and aluminum sulfate and 0.04 grain per gallon of sodium silicate. Additional studies are anticipated, including filtration through sand, Anthrafilt, soil, and various ion-exchange materials.

In preparing for future studies involving sludge digestion, the effect of recirculation upon the concentration of radioisotopes in the sludge materials was investigated. There appeared to be some beneficial effects from recirculation of the sludge, although the rate of gas production (on the basis of volumes of gas produced per gram of volatile matter consumed) and the total volume of gas produced were less than in the control non-recirculated bottles.

Rate controllers were designed for the sand-filter columns of the small model water-purification plant, and were constructed by the Health Physics Research Shop.

Studies and tests were completed in the development of a simple column apparatus for the treatment of small quantities of drinking water containing radioactive contaminants. This apparatus was found capable of reducing the activity level of water from 2.5 to less than 10^{-4} microcuries per milliliter.

Two members of the Health Physics Waste Research Group have been assigned and have spent a major portion of time in working with personnel on loan to the Laboratory who are engaged on special projects in connection with water-decontamination studies. The purpose is to obtain basic and practical data which may be of value in the treatment of water supplies for emergency purposes, including possible civil defense and military needs associated with the contamination of water supplies with radioisotopes.

SURVEY STUDIES AND ECOLOGICAL STUDY OF WHITE OAK CREEK DRAINAGE SYSTEM

Equipment is being assembled for an extensive statistically designed study to determine the controlled uptake of radioactivity by fish.

Routine well-logging has continued with at least two series of logs on all wells except three. As a result of the information obtained by logging, five wells were selected for more detailed study by an ion-exchange assay technique and radiochemical analysis where feasible. Subsequent probing of Well No. 41 east of burial ground No. 3 indicated

rather high activity. A sample of water from this well indicated that 57 per cent of the activity was due to ruthenium and 30 per cent due to cerium.

Arrangements are in progress for river studies to be undertaken cooperatively by ORNL and K-25. As a preliminary to planning studies, samples of water were collected from Clinch River mile 21.65 and mile 13.2 to determine minimum sample requirements. These samples indicated little evidence of stratification at the above two points. The "flounder" instrument measurements of radiation intensity from bottom muds made at the same time suggested that the velocity of water movement has resulted in the deposition of more radioactive contamination between K-25 and the Tennessee River than in the stretch of river above K-25.

Progress during the period in studies by the staff of the Ecological Study program has included the following:

1. A second determination of time of water travel under nonstratified conditions in White Oak Lake was completed. In general, both studies revealed complete dispersion in the lake. The fastest-moving water particle arrives at the dam in a time which corresponds to the displacement of approximately 15 per cent of the water volume in the lake. The passage of water through the lake is completed in a time corresponding to the displacement of slightly more than 100 per cent of the lake volume. For release of dye during a short period of time, the peak concentration reaching the dam was greatly reduced from the initial concentration, but for prolonged release there was virtually no reduction in concentration.

2. Age and growth studies were made on scale samples collected from fish during the spring population study. No variations from the growth and age distribution prevailing in nearby TVA lakes were observed. Spawning in White Oak Lake was observed during the spring, and both nesting and eggs taken from the nests appeared normal.

On May 14, 325 gravid female *Gambusia affinis* *affinis* were introduced into the settling basin, and within a very few days young *Gambusia* were dropped. Both the adults and the new-born appear to be surviving and growing well, in spite of an average activity during the past two months of 3.4×10^{-4} microcuries per cubic centimeter of water in the settling basin.

3. Collection of botanical specimens for the herbarium and preparation of various plant materials for radioassay continued. Generally speaking, the bark of woody species contained more radioactivity than any other part, while the leaves of herbaceous plants showed higher activity than stems or flowers. There is some indication in rose bushes that the activity may build up to a certain level during the first growing season and remain virtually unchanged thereafter. Identification of radioisotopes by adsorption curve analysis revealed the greater part of the activity in *Salix nigra* (black willow), *Cornus* (dogwood), *Rumex* (dock), and *Juncus* (rush) to be due to strontium^{90}-yttrium^{90}.

4. Studies of bottom organisms in White Oak Lake indicate that the productive zone is largely limited to the 0–3-foot depth. It is assumed that, below this depth, siltation is the limiting factor. Plankton collections revealed a *Volvox* bloom reached its maximum abundance during the middle of May and subsided to negligible proportions in June. It was replaced largely by rotifers and crustaceans.

5. Routine biweekly water sampling of White Oak Lake water for physical and chemical analysis was continued.

INSTRUMENTATION AND TECHNIQUES

Scintillation counting equipment is being built and tested for its utility in the survey of water and mud radioactivity and for biological sampling. For use in this work, electric-motor-operated equipment for grinding small crystals was completed and installed in a dry box.

The Bakelite detector housing for the well-probing equipment developed cracks and had to be replaced with a more rugged housing. Aluminum was used for the new unit which was altered to provide easier access to the detector tube and associated parts. At the same time, a more satisfactory water seal at the electric-cable entrance was developed. Trailers have been received and work begun on assembling two new well-probing outfits.

Since plans for alterations to White Oak Dam have been deferred, work has resumed and considerable progress has been made on the installation of facilities for monitoring and telemetering at this location.

Further experimentation with techniques for photoelectric measurement of the concentration of fluorescein dye used for flow measurement indicated that such an instrument for field use could be produced, but, to cover the desired range, would require more expensive equipment than could be justified.

The erection of the 35,000-gallon wood-stave tank (formerly a part of the ORNL water plant) which will be used for instrument calibration and evaluation was completed. Before contaminating it for calibration purposes, it is being used for several weeks by the U. S. Geological Survey for studies of submerged and distributed sources.

TRAINING ACTIVITIES

The two sanitary engineers mentioned previously who are engaged in work on problems for a master's thesis have been assigned to this section, and a member of the group serves on the two committees appointed to supervise their projects. One of these students will conduct studies on ion exchange in the removal of radioactive contaminants from water, and the other will study the efficacy of water-softening procedures for the removal of strontium^{90} - yttrium^{90}.

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THEORETICAL PHYSICS

FAST-NEUTRON TOLERANCE CALCULATIONS

Calculations of the maximum permissible flux of normally incident neutrons of 5 mev are nearly completed.

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

The stopping cross-sections have been computed, using the results of Hirschfelder and Magee (*Phys. Rev.*, **73**, p. 207 (1948)) and Knipp and Teller (*Phys. Rev.*, **59**, p. 658 (1941)). These values are being compared with the values obtained by means of the method of ORNL-884.

COLLISION DENSITIES FOR THERMAL-NEUTRON IRRADIATION OF THIN FOILS

In this study, we attempt to answer rather precisely the following question: How thick may a foil of a given material be taken so that the collision density within the foil, due to irradiation by a beam of thermal neutrons, will be constant to within k per cent? Graphs giving the required thicknesses are in preparation. The similar questions for irradiation for various angular distributions of incident flux are being considered.

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FAST-NEUTRON POCKET CHAMBERS

As previously noted, responses of hydrogen-free (graphite and aluminum-lined) chambers to artificial fast-neutron sources were higher than would be expected from the primary gamma radiation present. An attempt was made to differentiate fast-neutron from gamma effects by the use of a series of lead and iron shields. The lead series ranged from 1/32 inch to 1.5 inches, and the iron series ranged from 1/16 inch to 2.0 inches.

Table 1 shows results of responses in minometer readings of graphite- and polyethylene-lined chambers to cobalt^{60} gammas, polonium-beryllium neutrons and polonium-boron neutrons through some of the shields.

From these results, it is apparent that (1) while the gamma attentuation is exponential, the response to the neutron sources is not; (2) while the response of the hydrogenous chambers to neutrons is about three times that of the non-hydrogenous chambers, the response of the latter is still appreciable; and (3) while the percentage drop in response to a neutron source, because of shielding, is less for the hydrogenous chambers than for the graphite, the actual drop is very similar in the two cases.

These results indicated the possibility that (1) recoil carbon atoms were being measured in each case, there being a conducting coat of Aquadag on the polyethylene liners; or (2) there is a recoil or nuclear reaction in the gas itself – in this case, air.

If recoil carbon atoms were involved, they would have an extremely high specific ionization but a short path, in which case the leakage due to such ionization current would remain relatively constant if the gas pressure were lowered until the paths of such recoil atoms would just cross the chamber radius. A sealed graphite-lined chamber was

TABLE 1

Shield (inches)	Chamber Lining	100-Milliroentgen Cobalt^{60} Gammas	10^7 Polonium-Beryllium Neutrons	10^7 Polonium-Boron Neutrons
None	Graphite	290	30	17.5
None	Polyethylene	275	85	58
0.5 Pb	Graphite	108	21	12
0.5 Pb	Polyethylene	100	75	53
1.5 Pb	Graphite	26	16	10
1.5 Pb	Polyethylene	24	66	51
0.5 Fe	Graphite	144	27.5	16.5
0.5 Fe	Polyethylene	130	76	55
2.0 Fe	Graphite	51	19.8	11.5
2.0 Fe	Polyethylene	46	60	43

fabricated. This was attached by a tube to a plenum chamber which could be evacuated, and to which was also connected a mercury manometer to measure the air pressure. Exposure to both polonium-beryllium and polonium-boron neutron sources at various pressures failed to establish the presence of this carbon recoil effect.

The same plenum chamber will be used to test the gas effect. Other gases at measured pressures will be introduced into the system. By this means, it is hoped that the reactions involved can be identified.

MEASUREMENT OF RADIATION BY FREQUENCY VARIATION OF AN RF OSCILLATOR

Experimental investigations were initiated to measure nuclear radiation by observing the frequency variation of an RF oscillator in conjunction with an electrometer whose capacitance varies as a function of applied charge.

Charge leakage equivalent to irradiation of 5 milliroentgens per hour produced a frequency change of 1 to 2 cycles per second. The sensitivity of this method of radiation measurement can be increased manyfold by a proper design of the variable capacity electrometer.

A capacitive inductance controlled oscillator, as shown in Figure 1, will vary its frequency if the capacitance varies according to the expression,

$$\Delta f = \frac{\Delta C}{2C} f,$$

where f = frequency and C = the effective capacitance. A variable capacitance C_E (in Figure 1) is provided by an electrometer, as seen in detail from Figure 2. If the two electrode pairs are grounded electrostatically, a charged copper leaf can rotate between the two pairs of plates from a 45-degree rest position (lower detail) against the torsion of a steel wire or quartz fiber, moving into the space between the plates. The position of the leaf determines the capacitance between the electrode pairs 1 and 2 of the meter. The maximum capacitance will be reached when the leaf is lined up with the two electrodes. The two electrode pairs are electrostatically grounded, representing one electrode, but they remain two separate electrodes in the RF circuit, and since they are coupled by the movable leaf, they are providing the variable capacitance.

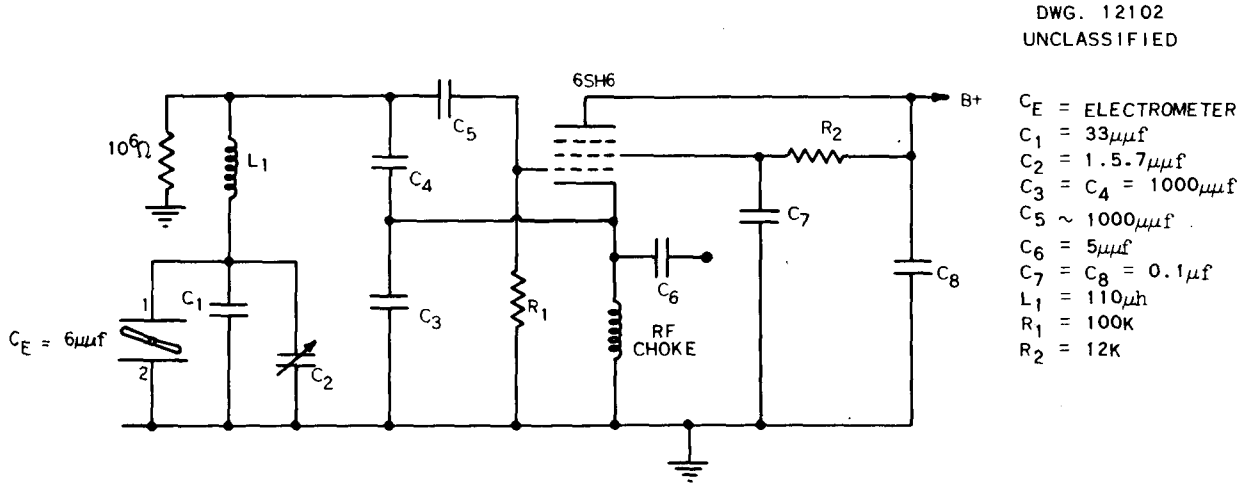

Fig. 1 – R-F OSCILLATOR AND ELECTROMETER

Figure 2 gives also the equivalent electrostatic and RF circuits. The amount of the electrical charge determines the leaf position and thus the frequency of the oscillator. The ΔC due to the leaf position varies up to about 0.5 micro-microfarad. Since the frequency-determining capacitance C (see Figure 1) was about 40 micro-microfarads and the operating frequency 2.2 megacycles, the frequency change for $\Delta C = 0.1$ micro-microfarad is about 2750 cycles. In order to stabilize the circuit, the equipment was used in an air-conditioned room. The high capacitances C_2, C_3 kept the influence of capacitance variations inside of the oscillator tube to a minimum. The frequency was measured by feeding the oscillator frequency into an amplifier and beating against a crystal-controlled oscillator. The beat frequency was measured with an interpolation oscillator by means of an oscilloscope. It was found that the frequency remained constant within a very few cycles over 1 hour and more.

When the leaf was charged, it took some time before the oscillatory movement of the leaf came to rest. A deflection of several thousand cycles (up to 7000) could be observed depending on the applied voltage, varying from 45 - 150 volts. Instead of applying the charge from a battery, a charged ionization chamber can be connected to the electrometer. Radiation applied to the meter of about 5 milliroentgens per hour produced a frequency change of 1 to 2 cycles per second.

The wire used for the suspension of the electrometer leaf shows some defects by not returning always to the same position when recharged, but

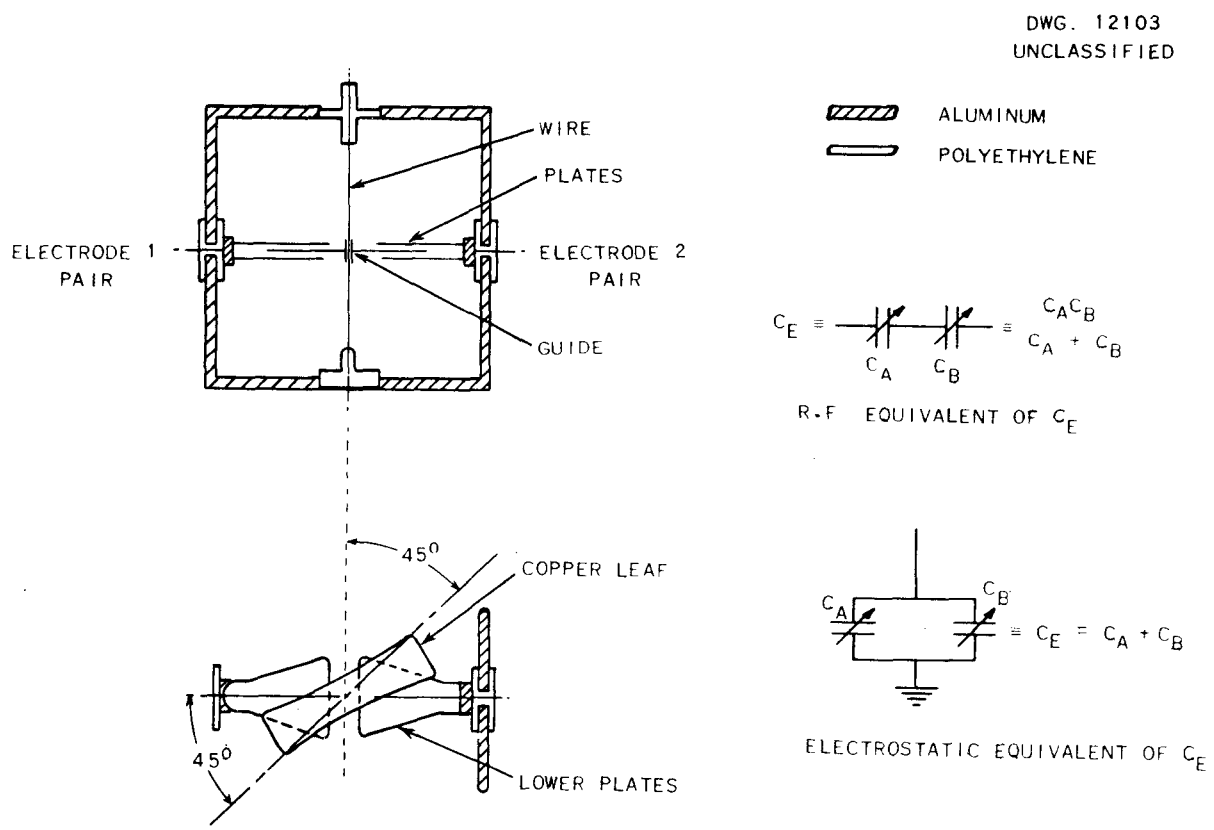

Fig. 2 – ELECTROMETER WITH VARIABLE CAPACITANCE

the zero position is usually kept within some few cycles. It is believed that this defect can be eliminated by improving the method of suspension, and it is intended to use magnetic damping to reduce the wire-leaf oscillations. The present investigations will probably lead to considerable variations of the experimental setup.

BETA PARTICLES

Absorption of a collimated beam of beta particles was measured with a thin-window counter down to 0.1 per cent of their initial intensity and a number of graphs recorded, using absorbers of different atomic number.

An anthracene scintillation counter has been assembled in which a gate circuit permits separation of different velocity ranges.

A cable with teflon insulation is being investigated with the purpose of connecting a thimble chamber directly to the electrometer. Measurements indicate that flexing of the cable does not introduce variations over an extended period of time in the electrometer current as is the case with other cables tested.

ENERGY MEASUREMENT OF BETA PARTICLES BY MEANS OF A MAGNETIC ANALYSER

Experiments have been continued on the absorption of the 626-kev conversion electrons from barium^{132}. The energy spectra have been obtained after passing through aluminum foils varying in thickness from 5.34 to 33.5 milligrams per square centimeter.

The most probable and average energy losses appear to vary linearly with the foil thickness. The experiments are now being continued with beryllium foils for the same range of thicknesses.

PARTICLE PROBLEMS

The completion of the radioactive particulate laboratory is expected in the near future. Particulate material data obtained from Project "F" will be presented in an ORNL report.

Investigation of isotope production showed again the need of a low-level-activity analytical laboratory for evaluation of airborne material. Percentage of gross beta found on the leached filters taken from constant air monitors operated near the gate to the restricted area were as follows:

	5-15-51 filter (per cent)	5-18-51 filter (per cent)
Barium	1.5	10
Total rare earth	115.0	28
Strontium	30.0	4 - 14
Ruthenium	10.0	0.5

Analysis of meterological, operational equipment, and monitoring data indicated that run No. 44 was a major cause of high air activity. The early air activity appears to come from processing of the metal waste, and is not all gaseous, but is composed of both gaseous and small particulates, whereas the latter high air activity is mainly particulate in nature and represents material processed during the latter stages of the operation. Radioautographs of filters taken from constant air monitors used during this period indicated higher specific activities in the latter particles than those observed during the earlier part of the run.

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RADIOCHEMICAL ANALYSIS

ANALYTICAL PROCEDURE FOR ANALYSIS OF URINE FOR RADIOACTIVE STRONTIUM

A survey of analyses of urine for fission products conducted at the Laboratory during the last two years reveals that, where measurable amounts of activity have been found, it has been due in most cases to the radioisotopes of strontium.

Since the present analytical procedure (described in AECD-2692) being used is designed to isolate a number of elements including barium, strontium, yttrium, lanthanum, and other rare earths, and is lengthy and time-consuming, it appears expedient to develop a procedure specifically for strontium.

Attempts at separating strontium from calcium on cation exchange resins have been most promising. Using Dowex 50 resin, it has been found possible to separate calcium from strontium with 0.1 molar ammonium citrate at a pH 5.5. The calcium is displaced from the resin more readily than the strontium. The peaks of elution of calcium and strontium are sufficiently apart to provide a separation of these two elements. Final details of the procedure are yet to be worked out.

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PHYSICS OF RADIATION DOSIMETRY

NEUTRON DOSIMETRY

Thermal-Neutron Survey Meter

The first model of a thermal-neutron survey meter has been completed and turned over to the Survey Section for field tests. The detector is a boron trifluoride proportional counter, having a sensitivity of 1 count per 150 thermal neutrons per square centimeter. Thus, a flux ranging from less than 100 to more than 20,000 neutrons per square centimeter per second can be measured rapidly and conveniently with a simple thyratron-powered rate meter. The volume of the counter is known, since hypodermic needles are used on the ends of the center wire to limit the region of gas amplification. Using the known volume and the thermal-neutron cross-section for boron, the count rate from an unknown field of thermal neutrons may be interpreted in terms of flux. This measure of the flux agrees to within 5 per cent of the value determined by the indium-foil method. The instrument is insensitive to radiations other than thermal neutrons.

Fast-Neutron Dosimetry

The work on the proportional-counter method of measuring fast-neutron tissue dosages, CF-51-4-122, has progressed in two respects. A special counter of this type was constructed containing on the inside a collimated alpha particle source which could be moved parallel to the axis of the counter. With this, a measurement of the sensitive volume of the counter and the way in which the gas amplification varied through this volume was made. The data were used to design a similar counter containing a fixed alpha particle source which could be exposed when needed for absolute energy measurements of the dose received from fast neutrons.

A new method of integrating the amount of energy represented by the recoil protons produced in the counter by fast neutrons has been developed with the cooperation of members of the Instrument Department. The method consists of feeding the output of a bank of discriminator tubes, biased to conduct at a series of carefully chosen voltages, into various stages of two binary-type scalers. The total reading of the two scalers is proportional to the dose, or total energy dissipated in the counter by the neutrons. The circuit, to be reported in detail later, has proved in preliminary tests to be very reliable and simple to operate.

An approximate calculation has been made of the wall losses in the count-rate fast neutron dosimeter (ORNL-930). The loss in net counting rate due to recoil protons which struck the walls before losing enough energy in the gas to be counted above the bias was determined. The result was that neutrons of 10 mev would produce a count rate not more than 10 per cent smaller than that previously calculated for this energy without considering wall losses and reported in ORNL-930.

SHIELDING CALCULATIONS

A preliminary value of 49.9 centimeters for the diffusion length of thermal neutrons in graphite has been computed from experimental data taken in the sigma pile. The single- and double-source data give results which agree to 1/4 of 1 per cent. A detailed report will be issued at a later date.

An approximate calculation has been made and reported to the Shielding Group of the energy dependence of a Hofstadter-type scintillation gamma spectrometer and a triple-coincidence scintillation gamma pair spectrometer (NEPA 1638). Also, the effect of wall losses upon energy resolution was found to be small.

The results reported in CF-51-4-103 on the correction of indium foil activations made in water have been found experimentally to be nearly independent of foil spacing. Thus, the correction factor given is a function of the foil thickness only, to a good approximation.

Calculations of the air scattering of neutrons using the exact solution in the one-velocity approximation (MT-4) have been carried out. The results are as follows:

r	$4\pi\lambda^2 rN(r)$
0.0	2.48
0.3	2.74
0.6	2.85
0.9	2.90
1.2	2.94
∞	3.00

where r is the distance in units of mean free path (λ) from an isotropic point source of unit strength, and $N(r)$ is the density of the neutrons which have experienced at least one collision. It is interesting to note that, if a first collision density is calculated, assuming no exponential attenuation in air, the result is

$$4\pi\lambda^2 rN = \frac{\pi^2}{4},$$

which coincides exactly with the above $r = 0$.

X-RAY CONTROL EQUIPMENT

In order to produce the small dose rates of interest in Health Physics, the controls of the 250-kilovolt constant-potential X-ray machine have been considerably supplemented. After extensive experimentation, an amplifier was designed with the assistance of the Experimental Radiation Measurements Section of this division. This consists of a Brown vibrator and transformer, a three-stage feedback AC amplifier driving a cathode follower, and a half-wave voltage doubler. The purpose is to take an input of 5 microamperes from the X-ray tube target and build it up to 0.5 milliamperes at 70 volts to run the stabilizer in the X-ray machine. The peculiar demands of the X-ray controls precluded the use of any conventional amplifier. Additional controls were built incorporating this amplifier and various safety features to prevent damage to the X-ray tube in case of failure or improper setting of the controls. It is now possible to produce stabilized currents from 5 microamperes to 20 milliamperes in the X-ray tube, giving dose rates from as little as 3 milliroentgens per hour at 30 kilovolts up to the full rating of the machine, several hundred roentgens per minute at 250 kilovolts. The beam can be confined to a cone as small as 0.16 degree, or opened up to the full aperture of the machine, 12.5 degrees each side of the axis of the beam.

An extensive dose-rate calibration is in progress so that in the future the proper voltage, current, and filtration can be set immediately for any desired dose rate and energy within the capacities of the machine. The calibration is being made both against a Victoreen roentgen meter and against an air-wall chamber of the type developed at the National Bureau of Standards.

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EDUCATION AND TRAINING

AEC FELLOWSHIP PROGRAM

The present group of twenty AEC fellows in Radiological Physics, having completed their academic work at Vanderbilt University June 6, transferred to the Oak Ridge National Laboratory June 11, where they are now doing their twelve weeks of field training.

TRAINING PROGRAM FOR MILITARY PERSONNEL

Six medical officers from Duke University completed their eight-week training course on May 25.

On June 9, nine military officers from the University of California and twelve from Ohio State University, two from the Army Chemical Center, Maryland, and one from West Point were assigned to this section for six weeks of training in health physics. Their training includes both lectures and field work.

TRAINING PROGRAM FOR AEC CONTRACTORS' PERSONNEL

On July 9 and 10, staff members of this section gave four lectures, totaling 5 1/2 hours, for duPont and the American Cyanamid Company.

This section has had the responsibility for the on-the-job training program for two senior health physicists of the Phillips Petroleum Company.

Three Health Physics surveyors from duPont and four from the American Cyanamid Company have been with this section since June for on-the-job training, and beginning July 16, this section has been giving special classroom work for the group, since it was felt necessary to supplement the on-the-job training.

A representative from the Health Physics Division of the Dow Chemical Company was with this section for approximately two weeks in June.

LECTURES

Two series of lectures have been conducted for ORINS, as well as lectures at King's College, Bristol, Tennessee; University of West Virginia; and Georgia Institute of Technology.

CIVIL DEFENSE

At the present time, we are engaged in revising the manual on *Radiological Protection* for the AEC.

MISCELLANEOUS ACTIVITIES

Members of the staff continue to assist in other teaching activities in the Laboratory, particularly in the Apprentice Training School and in the Reactor School.

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EXPERIMENTAL RADIATION MEASUREMENTS

BACKGROUND INSTRUMENTATION

In cooperation with the U. S. Geological Survey, a test probe for measuring slow neutrons in drill holes is being built. The counter is of the enriched boron trifluoride type. The slow-neutron density should be higher near uranium ore, due to spontaneous fission, and should also be specific for uranium. Tests will be made at Grand Junction, Colorado on a simulated test hole made up of layers of concrete and uranium ore. While the expected count will not be high enough to serve as an efficient ore-detecting device, it may serve as a check instrument on holes which have been logged with a gamma-ray probe and give further information as to whether or not the radium and uranium are in equilibrium.

A sodium iodide scintillation probe is also being constructed for test purposes on the simulated drill hole to test the feasibility of this type of probe. The possible advantages of the scintillation probe are greater sensitivity and the possibility of gaining further information from energy distribution curves. Knowledge of the energy distributions may make it possible to differentiate between a near small source and a distant large source.

Development of equipment used in the U. S. Geological Survey plane for radiation measurements is still in progress. The light piping from the 4-inch-diameter, 2-inch-thick sodium iodide crystal to the 5819 photomultiplier tube has been improved by making the Lucite light piper as short as possible. The next step in improvement is to mount the crystal directly onto the phototube.

An improved recording rate meter has been utilized which has no memory effect, obviates the use of scalers, and has a resolving time of the order of 2 microseconds. The device simply uses a small condenser, which is discharged by each count and then recharged from a large (1 microfarad) condenser. The voltage on the large condenser is then measured at the end of a counting interval with a recording electronic voltmeter circuit and recharged. Two large condensers are used alternately so that the voltage on one condenser is being recorded while the other is being discharged by the count. At the end of the counting interval, a switch reverses the connections so the condenser whose voltage was being recorded is charged and becomes the one to be discharged, and vice versa. The time interval of the switch is controlled by a Bodine motor with a relay, so that the time interval used is 1 second. Ceramic wafer switches mounted on a rotary solenoid did not stand up under continuous use. A new type switch is being constructed which, it is hoped, will remove this difficulty.

Work on radiation-absorption measurements is under way to find the perturbations introduced into White's results (*Phys. Rev.* **80**, 154 (1950)) by the presence of cylindrical air cavities of various diameters surrounding the detector.

AIR ACTIVITY STUDIES

Air activity studies were made at Gainesville, Florida and Corryton, Tennessee from April 13 to May 24, to detect any activity resulting from the recent Eniwetok tests. Twenty-four-hour air-filter samples were taken and counted twice at intervals of 4 and 24 hours after removal. After counting, each filter paper was radioautographed. Rainwater was also filtered and the filter papers processed the same way as air filters. Toward the end of the period, water used to rinse a plate collecting fall-out of particles was treated and studied for radioactivity. The highest long-life activity collected at Gainesville was of the same order of magnitude as the activity due to thorium B and thorium C content in air. At Corryton the highest

long-life activity collected was much less than normal thorium B and thorium C content in air.

The results of the air activity at Urbana, Illinois; Atlanta, Georgia; Nashville, Tennessee; Fort Worth, Texas; and Topeka, Kansas due to the earlier Nevada tests are appearing in a separate report.

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PERMISSIBLE INTERNAL DOSE - RADIOISOTOPES

PREVIOUS INVESTIGATION AND CALCULATIONS

Preliminary calculations of maximum permissible concentration (MPC) of radioactive isotopes in air, food, and water have been made on ten alpha emitters and twenty-eight beta-gamma emitters, using whatever data were available in the literature.

A thorough literature search revealed, however, that very little data had been developed regarding "critical body organs," normal concentration of various chemical elements in critical organs, the fraction of chemical elements inhaled, ingested, or absorbed through the skin that reaches the critical organ, and the biological half-life of the elements in the critical organs. These data, along with already available information regarding the energy and physical half-lives of the radioisotopes in question, are necessary in making calculations regarding maximum permissible concentrations.

Efforts have been directed toward obtaining these data by (1) publicizing the need for answers to specific questions among other Atomic Energy Commission laboratories and (2) ORNL sponsorship of research along these lines.

UNIVERSITY OF TENNESSEE RESEARCH AND DEVELOPMENT SUBCONTRACT

A research and development subcontract has been formalized with the University of Tennessee for the university to determine spectrographically the concentration of trace elements in human tissues and organs. Treatment of other subjects pertinent to this program is planned for the near future.

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CONSULTATION AND SPECIAL PROBLEMS

DISASTER EMERGENCY PROGRAM

Planning was completed on a program to cope with off-plant emergencies involving nuclear radiation. Personnel have been selected, and equipment and survey instruments have been placed at the Turnpike and Kerr Hollow Portals of the restricted area. Following a request from the AEC, personnel and equipment could be dispatched to the scene of an emergency with a minimum time delay. This program is coordinated with the interplant emergency program.

USE OF COMMERCIALLY AVAILABLE GEIGER-MULLER SURVEY EQUIPMENT WITH LIGHT AIRCRAFT TO LOCATE CONTAMINATED AREAS

Exploratory flight tests were made over a 6-curie cobalt^{60} source and isodosage curves constructed which indicated that a light aircraft flying at low ground speed and at an elevation of 500 to 1000 feet could be used with commercially available Geiger-Muller survey equipment to locate such point sources. Calculations indicated that such flights could be made to locate, at 500 feet elevation, areas where a relatively uniform surface contamination results in a tolerance dose rate near the surface of the earth (300 milliroentgens per week at about 3 feet above the surface). Significant surface contamination associated with radiological warfare could be located at a much greater elevation.

THERMAL NEUTRON MEASUREMENTS

Discrepancies in the response of boron-coated pocket chambers exposed to thermal-neutron fluxes at ORNL and at the National Bureau of Standards were investigated. A thorough check of the flux-evaluation method used at ORNL disclosed no apparent significant errors.

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PUBLICATIONS AND SPECIAL REPORTS

PUBLICATIONS

1. R. A. Lauderdale and A. H. Emmons, "Decontamination of Small Volumes of Radioactive Water," *Nucleonics*, 8, No. 5, 21-26 (May 1951). Also *J. Am. W. W. A.* (May 1951).

2. R. D. Birkhoff, "Distribution of Energy Loss of Electrons in Aluminum," *Phys. Rev.*, 82, 3, 448 (May 1, 1951).

3. J. Turkevich and H. H. Hubbell, "Low-Angle X-Ray Diffraction of Colloidal Gold and Carbon Black," *J. of Am. Chem. Soc.*, 73, 1 (January 1951). (Work done earlier at Princeton University. H. H. Hubbell now at ORNL.)

4. B. J. Spinrad, G. H. Goertzel, and W. S. Snyder, "An Alignment of Monte Carlo Solution of the Transport Problem," *Math Series* 12, Bureau of Standards (June 11, 1951).

5. O. R. Placak, "The Radioactivity Problems in Water Supplies," *Proceedings of the Inservice Training Course in Water Works Problems*, School of Public Health, University of Michigan (May 1951).

6. K. Z. Morgan, "Quantitative Limits of Permissible Exposure of Personnel (Internal and External)," *Manual of Lectures*, Inservice Training Course in Radiological Health, University of Michigan, School of Public Health (February 5-8, 1951).*

7. K. Z. Morgan, "Historical Sketch of Radiation Protection Experience and Increasing Scope of Radiation Protection Problems," *Manual of Lectures*, Inservice Training Course in Radiological Health, University of Michigan, School of Public Health (February 5-8, 1951).*

8. G. S. Hurst, "A Proportional Counter Method of Measurement of Fast-Neutron Dose," C. F. 51-4-122 (April 27, 1951).

9. E. O. Klema and R. H. Ritchie, "Preliminary Results on the Determination of Thermal Neutron Flux in Water," C. F. 51-4-103 (April 24, 1951).

10. F. P. Cowan and R. A. Love, Brookhaven National Laboratory, and L. B. Farabee, ORNL, "Health Physics and Medical Aspects of a Strontium^{90} Inhalation Incident," AECU-1169.

11. V. I. Knobf, "Studies of Radioactivity in Fish from White Oak Lake and the Clinch River," ORNL-1031 (July 9, 1951).

12. C. P. Straub and P. N. Hensley, "Experimental Jar Test Laboratory Stirring Device," ORNL-965 (May 1951).

13. E. E. Anderson, "Units of Radiation and Radioactivity," *Manual of Lectures*, Inservice Training Course in Radiological Health, University of Michigan, School of Public Health (February 5-8, 1951).*

**Manual of Lectures*, Inservice Training Course in Radiological Health, published May 1951.

14. E. E. Anderson, "Basic Principles of Radiation Protection," *Manual of Lectures,* Inservice Training Course in Radiolocical Health, University of Michigan, School of Public Health (February 5-8, 1951).*

SPECIAL REPORTS

1. C. P. Straub, "Radioactive Materials and Their Effects on Environmental Health," presented at Annual Meeting of Georgia Public Health Association, May 17, 1951.

2. O. R. Placak, "Disposal of C^{14} in Garbage," preliminary report to the Subcommittee on Waste Disposal and Decontamination.

3. K. Z. Morgan, "Maximum Permissible Concentrations of Radioisotopes in the Air, Water, and in the Human Body," preliminary report to the Subcommittee on Internal Dose (May 16, 1951).

4. Conrad P. Straub, "Experimental Water Treatment Plant. IV-Removal of Iodine (I^{131})," (April 30, 1951).

5. C. P. Straub, T. W. Brockett, and Robert Stepp, "Experimental Water Treatment Plant. V-Removal of Fission Products" (May 1, 1951).

6. C. P. Straub, "Water Decontamination. II-Studies on W-6 Tank Wastes" (May 2, 1951).

7. C. P. Straub, T. W. Brockett, and Robert Stepp, "Water Decontamination. III-Studies on Ce^{144}, Y^{91}, and I^{131}" (May 3, 1951).

8. C. P. Straub, and D. Pecsok, "Water Decontamination. IV-Mixed Fission Products, Factorial Experiment" (May 29, 1951).

9. C. P. Straub and D. Pecsok, "Laboratory Studies with Adsorbents. I-Variable Activity Concentration and Mixing Time. W-6 Tank Waste" (May 4, 1951).

10. C. P. Straub, D. Pecsok, and T. W. Brockett, "Laboratory Studies with Adsorbents. II-Bentonitic Montmorillonite Clay. Variable Radioactivity and Adsorbent Concentrations. W-6 Tank Wastes" (June 2, 1951).

11. C. P. Straub and D. Pecsok, "Laboratory Studies with Adsorbents. Variable Adsorbents. Effect of Salinity and Acidity. W-6 Tank Wastes" (June 3, 1951).

12. C. P. Straub, "Disposal of Radioisotopes. A Method of Evaluating Potential Hazards" (April 14, 1951).

13. R. J. Morton, "Problems of Control and Disposal of Radioactive Waste Materials," Public Health Engineering Conference, College of Engineering, University of Florida (March 29, 1951).

**Manual of Lectures,* Inservice Training Course in Radiological Health, published May 1951.

14. T. H. J. Burnett, "Hazards from Released Activated Sodium" (February 8, 1951).

15. T. H. J. Burnett, "Shielding Estimate - LITR Irradiation 'Bomb' " (February 20, 1951).

16. T. H. J. Burnett, "Comparative Dosage Study: Ra vs. MsTh." (The above reports are recorded here because they were not previously reported.)

17. M. A. Churchill, "Investigations of Water Movement in White Oak Creek and Lake," TVA Hydraulic Data Branch (June 22, 1951).

18. D. M. Davis and J. C. Hart, "Aerial Surveying with Light Aircraft for Radioactive Contamination on the Ground" (June 30, 1951).

19. E. J. Kuna, "A Radioautographic Study of X-10 Area - December 3, 1950 through January 5, 1951" (June 13, 1951).

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