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ORNL 695
Progress Report

HEALTH PHYSICS DIVISION
QUARTERLY PROGRESS REPORT FOR PERIOD ENDING APRIL 15,1950

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Progress Report

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HEALTH PHYSICS DIVISION

K. Z. Morgan, Director

F. Western, Associate Director

QUARTERLY PROGRESS REPORT
for Period Ending April 15, 1950

DATE ISSUED: MAY 26 1950

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This report covers the activities of those groups in the Health Physics Division primarily engaged in Applied Research or Development. More or less routine activities of the Survey-Monitoring Section are covered in the Laboratory Weekly Progress Report.

INSTRUMENT DEVELOPMENT

Fast Neutron Program. **A.** The calculations describing a proportional counter applicable to a portable fast neutron dosimeter, where the neutron dosage is indicated directly by a counting rate, are included in a report ORNL 589[1] issued February 17, 1950. Since that date, refinement of some of the assumptions have been made, and experimental counters to test the theories involved have been constructed. Test measurements using various monoenergetic neutron beams provided by equipment at Los Alamos are scheduled to take place about April 10-14, 1950.

B. A report, ORNL 590[2] issued March 21, 1950, describes a Fast Neutron Continuous Monitor and Survey Meter. The survey meter has a count rate meter with full scale values of 50, 1,000, and 10,000 neutrons/cm^2/second. The instrument will discriminate against gamma radiation up to about 10 r/hr. The probe is connected by a 12 foot cable to a power supply permitting the use of the probe as a survey instrument. An alarm circuit is provided. The instrument is powered by the 110 volt 60 cycle line. One model of this instrument is in operation and will be observed for reliability and general performance.

C. Work is proceeding on the design and construction of a proportional counter to have a uniform response or count rate sensitivity related to neutron energy, where the neutron beam may have energies between 0.5 Mev and 15 Mev. The application of this counter is to measure total emission of such sources as Po-Be, Ra-Be, etc., and an objective is increased accuracy over present methods of such source measurements.

D. A proportional counter to have equal sensitivity in all directions is being developed. The application of this counter will be largely for shielding measurements and monitoring.

Portable Alpha Survey Meter. **A.** Report ORNL 602[3] issued March 14, 1950, describes the subject instrument which, briefly, is a proportional counter, gamma discriminating, battery operated, survey meter of four pounds total

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(1) Hurst, G. S., *Fast Neutron Count-Rate Dosimetry*, ORNL 589 (February 17, 1950).

(2) Farber, R. J., *Fast Neutron Continuous Monitor and Survey Meter*, ORNL 590 (March 21, 1950).

(3) Hurst, W. M., Hurst, G. S., and McDonald, W. B., *A Portable Alpha Survey Meter*, ORNL 602 (March 14, 1950).

weight. Operation in a high humidity is achieved by the use of silica gel in the probe and some effort is now being made to eliminate the silica gel by the use of guard rings. Twelve instruments are ordered for further field testing. Some consideration is being given to the possibility of a commercial production contract.

Constant Water Monitoring. A. This problem has been worked on for one month. Exploratory work is contemplated for a period of about six more months at which time we will want to freeze on the type of detector to be used and construct a laboratory model.

Beta Dosimeter. A. This problem is to be attacked starting April, 1950, and the objective is a survey instrument, possibly operated from 110 volt line, for use in scanning laboratory tables, equipment, and machinery.

WASTE DISPOSAL STUDIES

During this period there have been no major changes in the research staff and facilities of the Waste Disposal Research Section. There have been some important changes in the work program, particularly increased emphasis on laboratory studies of processes for water decontamination, and extensions of cooperation with other groups and agencies and the development of joint research projects.

Water and Liquid Waste Decontamination Processes. The small model water treatment plant set-up has been completed in a laboratory of the Health Physics Building. Numerous items of experimental and control equipment have been procured and installed making the plant practically automatic in operation. These include a weir type effluent collecting and sampling container, a constant head multiple orifice feedbox, lucite tubing rapid sand filters, Flowrator control devices, a supporting stand for the feedbox, and other necessary accessories. A preliminary run with the Spaulding precipitator has been carried out without radioactive materials and with comparative use of alum and ferric chloride as a coagulant.

Extensive series of experiments on coagulation and precipitation processes for the decontamination of liquids have been continued. The purpose is twofold: (1) to evaluate the action of usual water coagulation processes in the removal of typical radioisotopes and mixed fission products; (2) to find and evaluate the coagulant aids that can be used effectively and without too much modification in conjunction with conventional water and waste treatment procedures. The study is planned to include a wide range of operating conditions as found in typical water plants. Experiments thus far have included tests upon the removal of cerium 144, zinc 65, yttrium 91, and tungsten 185, and a number of other isotopes have been obtained for use in future series of experiments. Preliminary results indicate very good efficiencies in the removal of the isotopes tested from very low as well as from moderate concentrations in water.

Further laboratory tests of a sample of East Pond water have been made in the study of adsorption of activity on particles of kaolinitic clay, and radiochemical analyses are being made to determine the sources of activity in this

sample. Previous results were confirmed and a report on this project is being prepared.

Studies of sewage treatment processes have included an additional series of sewage digestion experiments begun on January 28 and completed near the end of March. For further study of the action of sewage filters in the concentration of radioactive materials, a number of the six foot sewage filter columns arranged for sampling at intervals of one foot depths have been completed by the Research Instrument Shop.

The proposal for construction of a laboratory and pilot plant building for research in water and liquid waste decontamination has been approved and the Division is authorized to proceed with this project. With cooperation from the Engineering and Maintenance Division the change recommendation (CR-75 Revised) "Facilities for research in water and liquid waste decontamination" and preliminary plans for the building have been completed and design criteria for the building and equipment to be procured under contract are being prepared. In addition to the Health Physics Waste Disposal Studies, these facilities will provide for research projects of particular interest to the Public Health Service and to military agencies, and a plan for cooperative work by which these agencies will participate in water and waste decontamination studies at ORNL has been developed. At a conference on April 12 in the Health Physics Division, representatives of the Public Health Service, the Armed Forces, the AEC and ORNL were present and a framework of general policy and plans for this program of cooperative research was adopted.

Survey Studies of White Oak Drainage System and Clinch River. The contract between AEC and TVA covering an Ecological Study of White Oak Drainage System was drawn up and approved in January and general plans for the study have been completed. The stated general purpose is (1) to determine what radioactive elements have accumulated in living things in the stream, (2) where they have accumulated, and (3) what has been the effect on survival rates, population balances, and types of organisms. This is a comprehensive long range program with which ORNL will cooperate and work jointly since the study includes many questions with which the Health Physics research program is concerned. Major sections of the work plan include a physical survey of the White Oak Creek Drainage area, a limnological study, fish population biology,

and a radiological study of the drainage area possibly as far down stream as Watts Bar Dam. An advisory committee was formed and has held two meetings. General direction of the study and the physical survey is a function of the Health and Safety Division of TVA. Detailed studies of fish and fish food biology are to be conducted by the TVA Fish and Game Branch. Much of the radiological study will be performed by the Health Physics Division as a part of the program of waste disposal studies or through analytical and assay services rendered to TVA. Use of the data obtained and supplementary studies are to be made by the Waste Disposal Research Group in order to interpret the results of the Ecological Study from the viewpoints of Health Physics.

Work in connection with the White Oak Drainage System has been continued both as a part of Waste Disposal studies and in preparation for the Ecological Study mentioned above. This has included (1) field measurements of the volume of flow through White Oak Dam at various water elevations to provide a more accurate rating curve, (2) review of data and preparation of drafts of reports on all previous fish studies in White Oak Lake and Clinch River, (3) progress toward the completion of the continuous monitoring installation at White Oak Dam, and (4) plans for a re-survey of radioactivity in mud deposits above White Oak Dam.

The AEC Geological Survey project has completed the core drilling of 51 test wells totaling 4500 feet of holes for the study of ground water contamination. The Health Physics Division is cooperating in probing and analyses for radioactive measurements in these wells. A special probing detector with about 200 feet of cable and indicating-recording instruments has been assembled to permit logging of the test wells after they are completed and several wells have been measured and reported. It was agreed that all wells should be probed for evidences of radioactivity above natural background, that pulverized rock samples of the cores from representative strata should be counted and analyzed, and that radiochemical analyses of water samples from selected wells should be made by the Waste Disposal Research Group.

Instrumentation. For the probing of test wells mentioned above a probing detector has been constructed and tested in manual operation. An automatic reel and recorder assembly for the well probe has been designed and assigned to the shop for construction. Other work has included preliminary design and

testing of a small probe for scanning fish specimens for radioactivity, further design and testing of a detector for continuous monitoring of water at White Oak Dam, and preliminary work on a special probing instrument for mud surveys.

A small radiochemical laboratory has been equipped for analyses in connection with the TVA-AEC Ecological Study and in the regular program of waste disposal studies; active work has been done in the adaptation of radiochemical techniques for use with organic specimens and the other types of materials involved in these programs.

Miscellaneous Activities. Liaison has been maintained and several conferences have been held with members of the Chemical Technology Division for exchange of information, coordination of Waste Disposal Research activities, and preparation of material to represent ORNL in the new AEC working group on waste disposal problems.

As a result of a flood in White Oak Creek in January, temporary measures were taken to provide emergency protection against overflow of the roadway and possible destruction of the dam. Members of the Waste Disposal Research Group have collaborated with design engineers and others in the development of plans for permanent changes in the dam to eliminate flood hazards.

THEORETICAL PHYSICS

Ionization and Excitation Losses of Charged Particles Traversing Matter. Efforts are being made to fit the available data into the formulas previously derived in order to determine the oscillator strengths of a Fermi-Thomas atom. These oscillator strengths are the only empirical constants which are necessary in order to evaluate the energy losses of heavy particles of intermediate energies.

The only available data are from the stopping power measurements of protons in the various substances performed by S. D. Warshaw.[1] Unfortunately, these measurements cover a low energy range (below 600 Kev) and, therefore, the data do not appear to be very useful.

Consideration was given to the stopping power calculations made by Hirschfelder and Magee[2] using the Bethe theory. These calculations cover the intermediate energy range and, therefore, could be used for determination of oscillator strength. However, it was found that the calculations are quite unreliable since in the low energy range they differ from the measurements of Warshaw by 35 to 40 percent.

Interpretation of Cross Section Data. During the recent few months, the Mathematics Panel was engaged in interpretation of cross-section measurements performed by Dr. S. Bernstein and his associates. In that connection a certain amount of theoretical and experimental material has been compiled justifying the assumption that the neutron width of the element under consideration is as follows:

$$2.3 \times 10^{-3} \sqrt{E_0} > \Gamma_n > 0.3 \times 10^{-3} \sqrt{E_0}$$

where E_0 is the resonance energy in ev.

Fast Neutron Problem in Tissue. The problem is now on the calculating machines and the fifth collision calculations are completed. There has been

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(1) Warshaw, S. D., "The Stopping Power for Protons in Several Metals," *Phys. Rev.* 76, 1759 (1949).

(2) Hirschfelder, J. O. and Magee, J. L., "Range-Energy Relations for Protons in Substances Containing C, H, O, A, and Xe," *Phys. Rev.* 73, 211 (1948).

considerable delay due to machine trouble, but the neutron histories should be available in a matter of weeks. Preliminary studies are in progress to determine the most effective method of handling this data for tolerance calculations.

EXPERIMENTAL PHYSICS

Apparatus previously used for determination of radon content of air samples and radium content of water samples is being overhauled. When reconditioned, this apparatus will be used for radium analyses of core samples from bore holes in an effort to correlate radium content with natural background variations observed in the logging of these holes with a Geiger counter probe (See discussions of core drilling project under "Water Disposal Studies.")

As a part of the program of studies of dispersal of stack gases in the atmosphere two of four high pressure ionization chambers containing 100 cubic feet of argon each have been installed at distances of approximately one and three miles east of the stack. The other two will be placed as soon as lines are available at corresponding distances to the west of the stack. All four chambers will feed into recording apparatus in Building 104-B. Since the winds are usually up and down the valley, the two chambers upwind will act as background measurements to subtract from the activity measured downwind from the stack. Three trailers containing apparatus for measuring air contamination are near completion. It is intended to place at least two of the trailers at positions occupied by the high pressure chambers.

Approximately one month's time of two people in the section was devoted to the US Geological Survey for the purpose of instrument design and use in aerial prospecting for uranium. The present sensitivity of the apparatus is the detection of small outcrops of 0.1% ore while flying at 500 feet above ground. It is desirable to have a sensitivity of about ten times this which means counting rates of the order of 100 times the present. Attempts to approach this sensitivity are being made by using bundles of large Geiger counters and also by use of large crystals of sodium iodide as scintillation counters.

SPECIAL PROBLEMS

Surface Dose of Uranium. Enriched uranium was investigated to determine the alpha and beta dose. The details and results will be given in a later report, ORNL 697.

Backscattering of Beta Particles with an Extrapolation Chamber. The previous experiments with P^{32} were continued. The source was deposited on the inside of the upper electrode, consisting of rubber hydrochloride made conductive with aquadag. The mass was less than one mg per cm^2.

The primary beta radiation, the backscattered electrons, and the ions produced a current through a resistance from the collector to ground. The voltage across this resistor was measured. The rubber hydrochloride was usually the negative electrode and the collector was the positive one. The distance between the upper electrode and the collector was varied from about 1 mm to 0.5 mm to obtain a correct extrapolated value.

The contribution of several collector materials to the backscattering was investigated. The current increases considerably with increasing atom number Z of the collector. A correction of about 1.75 percent for beryllium collector should be made to account for backscattering from the rubber hydrochloride. Theoretically the following observations should be expected:

Setting:

I_β = primary beta current

m = average number of ion pairs per primary beta

l = average distance between collector and source

s = number of backscattered electrons per primary beta

n = number of ion pairs per cm produced by backscattered electrons

I = total current through collector

It shall be assumed that all the backscattered electrons are reaching the negative electrode.

It follows then:

$$(1) \quad I = I_\beta \; [\, l + ml - s + snl \,], \quad s = f(Z)$$

$$(2) \quad dI/dl = I_\beta \; [\, M + sn \,], \; n > m,$$

since the backscattered electrons have a lower velocity than the betas, and are producing more ions/cm. Since s increases considerably with Z, the intercept for $l = 0$ on the I - l coordinates should decrease with increasing Z, while according to (2), the slope dI/dl should increase. While the second conclusion was confirmed qualitatively, the first one is not yet proved. The investigations are still in progress.

Backscatter Measured with Beta Counter Filled with A and CH_4. A special construction of the ionization chamber makes it possible to limit the backscattering to that of the source carrier, that is, rubber hydrochloride. The backscattering material can be supported in such a way that it contacts the outside of the rubber hydrochloride very closely. The source itself is on the inside of the rubber hydrochloride and has a geometry of nearly 50 percent. The construction permits a rapid exchange of backscattering material without opening the ionization chamber.

A. *Backscattering from the thick materials:* The intensity of the backscattered electrons has been plotted in percents of the beta radiation without scatterer. The following results were obtained:

	Z	INTENSITY IN PERCENT OR RADIATION WITHOUT BACKSCATTERER
Polystyrene	6	23%
Al	13	31%
Cu	29	43.5%
Cd	48	49.5%
Pb	82	58.5%

B. *Backscattering with materials of varying thickness.* Al, Zn, Sn, Pb, were investigated from about 5 mg/cm^2 for Al; 15 mg/cm^2 for Pb; 40 mg/cm^2 for Sn and Zn up to saturation backscattering for each element. The increase of intensity with weight is larger for higher atom numbers and approached saturation for about 100-150 mg/cm^2. The details are still under investigation (Figs. 1 and 2).

For 30 mg/cm^2 backscatter of Al, Zn, Sn, Pb, the experimental values were reduced to the relative backscattering for the same number of atoms. It appears that the backscattering increases like constant $\times Z^n$. $1 < n < 2$. Further investigations with very thin foils are required to give dependable results.

Absorption of Beta Particles. A number of experiments have been started with the beta counter using collimation.

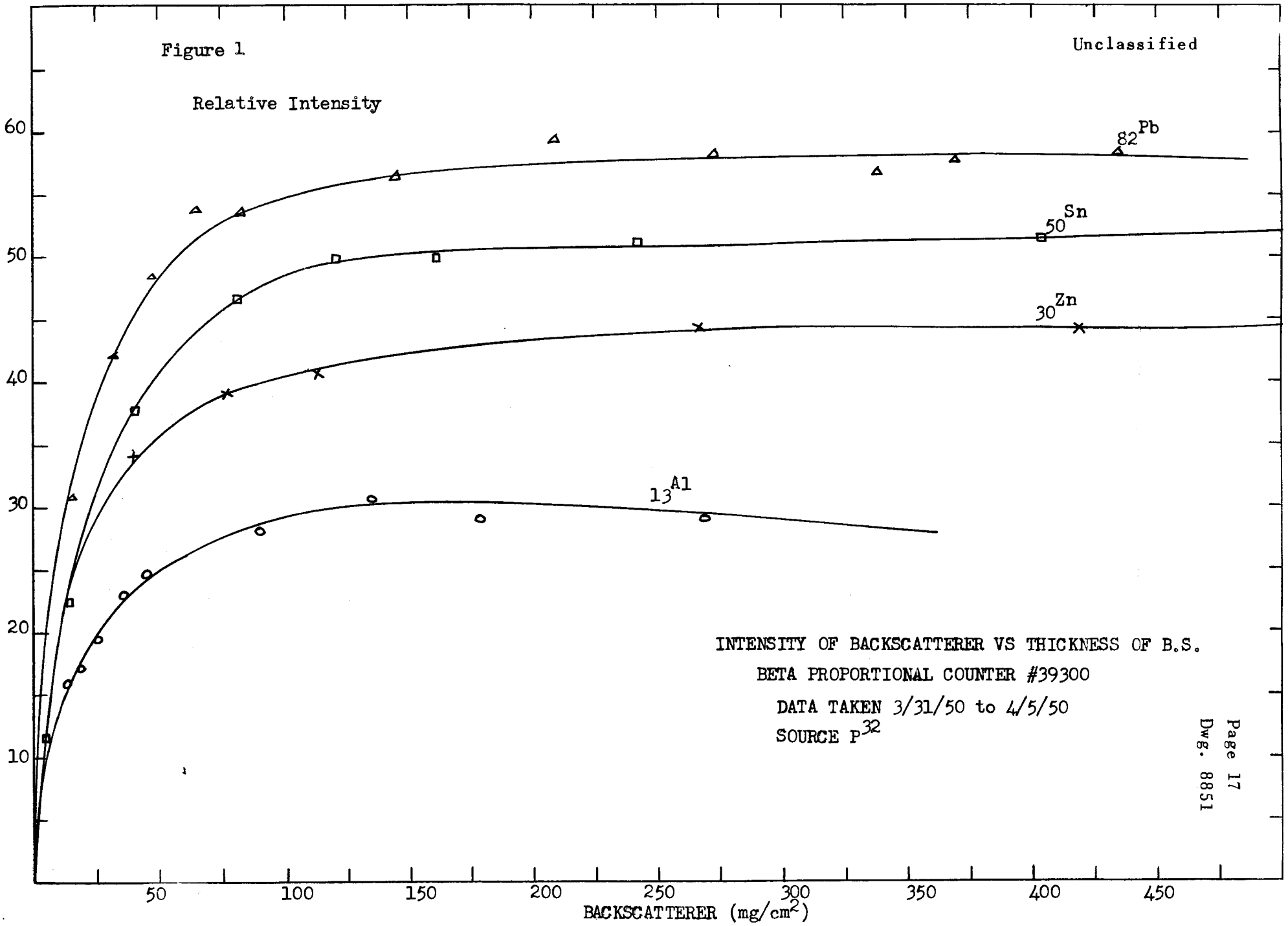
Neutron Monitoring. **A.** Resistance changes of Pd resistors as observed and reported by B. R. Gossick[1] when covered with hydrogeneous materials under neutron bombardment were investigated. Most tests were made without enamel coating. The resistances ranged from 50 K to about 1,000 K. Preliminary tests with 6×10^6 roentgens from cobalt did not show any measurable response.

The changes by temperature were very troublesome. The resistances were, therefore, divided in groups, kept above and below room temperature for awhile, and their return to the original values were measured. It seems that the thermal history is an important factor in the resistance value. These superimposed thermo-effects are somewhat unpredictable and make it very difficult to observe small resistance changes due to fast neutrons. Exposure to $\sim 6.8 \times 10^4$ weeks tolerance doses of fast neutrons produce drops in resistance from 0.5% to 3%, the higher resistances giving the higher percentage. These changes are showing healing effects with half-life times of 4 - 5 days. B. R. Gossick obtained the large and permanent changes with radiations of several magnitudes higher.

(1) Gossick, B. R., "Pd Film Fast Neutron Detector," *Phys. Rev.* 77, 297 (1950).

Figure 1

Unclassified



INTENSITY OF BACKSCATTERER VS THICKNESS OF B.S.

BETA PROPORTIONAL COUNTER #39300

DATA TAKEN 3/31/50 to 4/5/50

SOURCE P^{32}

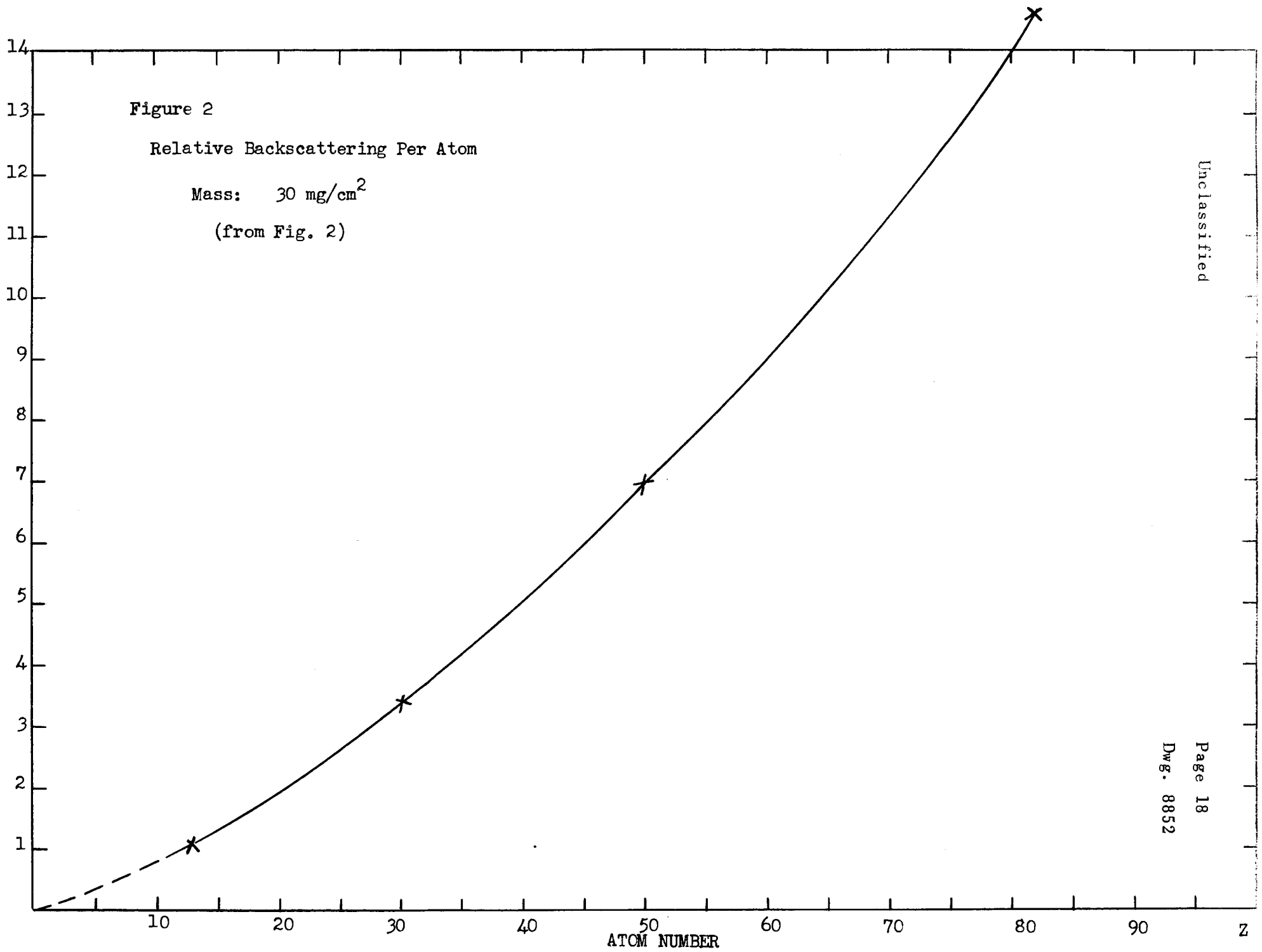


Figure 2
Relative Backscattering Per Atom
Mass: 30 mg/cm^2
(from Fig. 2)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Z
ATOM NUMBER
Unclassified
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URINALYSIS

Analysis of Urine for Radioactive Strontium. The results of an exploratory survey of excreted beta-gamma emitting fission products in urine have emphasized the need for an analysis procedure which is specific for strontium. The procedure used in the survey isolated a group of elements including strontium, barium, yttrium, lanthanum and associated rare earths in one operation. Due to the low level of activity which was found in most of the urine samples, it was difficult to determine the radioactive element or elements present by conventional absorption curve and/or decay studies. A change in the procedure is recommended in the event an analysis for strontium alone in urine is needed.

The analysis procedure described in report ORNL 368[1] provides separation of Sr, Ba and the rare earths from Ca and Mg by precipitating $SrCrO_4$ and $BaCrO_4$ from a chromate solution at *p*H 8 in the presence of alcohol. The suggested change would separate Sr from Ca and Mg by a $Sr(NO_3)_2$ precipitation from a 70% nitric acid solution. The Sr can then be recovered as $SrC_2O_4 \cdot H_2O$. The percentage recovery can be determined gravimetrically by comparison of the recovered Sr with the Sr tracer originally added to the urine sample. The beta-gamma activity can be determined by conventional counting procedures.

Eighteen urine samples have been assayed for strontium by this procedure. An average recovery of 90.3% ± 5.6% has been achieved.

Method for Removing Impurities from Lanthanum. When water or urine samples with plutonium activity of approximately 5 d/min are assayed using lanthanum as a carrier, it is desirable to eliminate the radioactive impurities normally present in lanthanum. Impurities may be found in commercial lanthanum compounds which will contribute extraneous alpha from 1 to 2 d/min/mg. Some beta-gamma activity will also be present. Lanthanum can be separated from these impurities satisfactorily by use of synthetic cation exchange resins.

Essentially the separation can be made as follows:

1. Use of Dowex - 50 resin (40 to 60 mesh) in a cylindrical glass column approximately 3 ft in height.
2. Put onto resin column the lanthanum in 0.1 *N* HCl (1 gm La per cm^2 of resin bed).

(1) Tompkins, P. C., Farabee, L. B., and Ehym, J. X., *Procedure for the Radiochemical Analysis of Barium, Strontium and the Rare Earths in Human Urine*, ORNL 368 (October, 1949).

3. Elution of lanthanum from the resin with 5% citric acid at a *p*H of 3.4 at a flow rate of 0.1 cc/min/cm^2 resin.

4. Recovery of lanthanum as lanthanum oxalate.

5. Two re-precipitations of lanthanum oxalate.

6. Ignition of the oxalate to La_2O_3.

By this procedure lanthanum has been prepared with alpha activity less than 0.02 disintegrations/minute/mg. This represented removal of more than 99% of the alpha impurities essentially present. The removal of beta-gamma emitting impurities was also good.

EDUCATION AND TRAINING

1. During this quarter, the eleven NRC Fellows who began their year's training here October 5, 1949, have been occupied with basic courses in Nuclear Physics, Mathematics, and Elementary Biology. In addition most of the fellows have been working on regular Research projects in the Health Physics Division, the Biology Division or the Chemistry Division.

2. Five medical officers from Duke University (the sixth is still waiting for clearance) came to the Laboratory April 3, for an eight week training period.

The training program for these men consist of field training supplemented by lectures in Health Physics and related subjects.

3. Considerable time has been devoted to planning for the Civilian Teachers Training Course in Radiological Defense, jointly sponsored by the Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies.

The course now in progress began April 3, and will continue for a period of five weeks. The Laboratory has taken full responsibility for the field test. This section has drawn heavily on other members of the Health Physics Division for teaching and planning this course.

4. On March 6, the first draft of the Manual of Radiological Protection for Civilian Defense was completed and sent to Washington for a classification check and distribution to the training centers. Since that time, the section has been busy correcting, revising, and editing the manual, which should be ready for final distribution in the near future.

5. The reorganization of the AEC Fellowship Program for next year has been completed. The ORINS has the administration details of the program of the training being given at Vanderbilt University and the Oak Ridge National Laboratory. Vanderbilt University will grant graduate credit for this program. Present plans are that the student will spend the first quarter at Vanderbilt, and the next nine months at the Laboratory. Those students, to whom a six months extension in their fellowship is granted, will spend an additional two

quarters at Vanderbilt earning master's degrees in science. It is expected that the research problems will be done at the Laboratory.

The preliminary selection of candidates has been completed for next year. There were 200 applications for the Fellowship. The number to be trained at ORNL has been increased to 20 for next year.