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ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

Donald I. Walker

Director

UNITED STATES ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
P.O. Box 2108
Idaho Falls, Idaho
83401

ABSTRACT

The 1971 Annual Report of the Health Services Laboratory, Idaho Operations Office, is issued to document the staff's efforts and to highlight the major activities of the Laboratory during the year for the benefit of those who share the nuclear fields of interest with us. The Laboratory's primary responsibilities are to the National Reactor Testing Station to provide needed and meaningful services to the many operating contractor organizations and to provide assurance that environmental effects on and off site are not only within established guides, but are as low as practicable.

Again, we solicit inquiries concerning details of our efforts and welcome a general exchange of information on these selected topics.

Donald I. Walker, Director
Health Services Laboratory

CONTENTS

FIGURES

TABLES

1971 ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

1. INTRODUCTION

The Health Services Laboratory (HSL) is composed of the Analytical Chemistry, Dosimetry, Environmental, and Instrumentation Branches, and a Medical Department. Additionally, the U.S. Geological Survey (USGS) and the Air Resources Laboratories Field Research Office of the National Oceanic and Atmospheric Administration (NOAA) maintain technical staffs at the National Reactor Testing Station for which the HSL provides programmatic direction for their NRTS activities. The Organizational Chart for the Laboratory, effective December 31, 1971, is included as an appendix to this report. On that date there were 74 HSL, 5 USGS, and 10 NOAA employees at the Laboratory. There were no major organizational changes during 1971.

The main efforts of the Laboratory are directed toward the operating contractors and the programs of the National Reactor Testing Station. The Laboratory provides a broad occupational-industrial medical program, a wide spectrum of personnel and operational dosimetry capabilities, diverse types of portable radiation instrumentation, and both chemical and radiochemical analytical services. The Laboratory is also assigned the responsibility for evaluations, on- and offsite, of all radioactive and nonradioactive materials that may affect the environment of the NRTS. A broad surveillance program for monitoring air, water, milk, and vegetation that may be affected by the NRTS operations is performed by the Laboratory to comply with AEC and other applicable guidelines.

An integral part of the routine programs of the Laboratory are extensive research efforts, designed to increase both our capabilities in providing services and scientific knowledge in general in these fields. During 1971, about 9% of the Laboratory's funding was provided by the AEC's Division of Biology and Medicine for studies on the toxicity of radioelements, on the deposition of airborne radioactive contaminants, and on the ultrasensitivity of analytical techniques through neutron activation.

Almost 17% of the Laboratory's manpower was expended in providing a variety of services to AEC's Regulatory Program in their surveillance of licensed facilities including nuclear power stations, and fuel fabrication and fuel processing plants. This involved such work as chemical analyses, environmental dosimetry, data analyses, and providing equipment, supplies, and various samples to Regulatory's regional office staffs. These efforts have also required a significant amount of research and development in order to supply the requested services. Much of this work has proved to be applicable to the environmental problems of the NRTS also.

II. ANALYTICAL CHEMISTRY BRANCH
(C. W. Sill)

1. 1971 ANALYTICAL CHEMISTRY BRANCH ACTIVITIES

1.1 Routine Analytical Chemistry Activities

The Analytical Chemistry Branch of the Health Services Laboratory maintains the capability of providing chemical or radiochemical analyses for virtually all chemical elements and radionuclides in a wide variety of environmental and biological samples. The primary responsibility is to provide analytical services in support of operations at the NRTS, including work generated by NRTS contractors and the operational problems of the Health Services Laboratory. The other major source of routine analytical work comes from the Office of Regulation. This includes analyses of environmental samples obtained during routine surveillance of the licensees under each of the regional offices of the Division of Compliance, as well as similar samples resulting from the Independent Measurements Program. This latter program involves an independent verification of the types and quantities of radioactive materials actually released to the environment by licensees operating nuclear power reactors and other nuclear facilities located throughout the entire United States.

During the past year, over 16,500 analyses were made on some 10,000 samples of many different types, 381 direct *in vivo* measurements on humans were made, and a total of 583 electrodepositions were performed. The analyses, most of which were made at extremely low levels, included most fission products, the transuranium elements, and the heavy element daughters of the naturally occurring series.

Detection limits revised to November 1971 for the major analyses performed in the Laboratory are given in the appendix to this section.

1.2 Independent Measurements Program (R. L. Kirchmeier, G. E. Grothaus)

The purpose of the Independent Measurements Program is to determine at the request of the Division of Compliance (the AEC Regulatory Program) the quantities and types of radioactive materials actually being released to the environment by various licensed facilities in the United States. The five facilities include a nuclear fuels chemical reprocessing plant, a scrap recovery/fuel fabrication plant, a commercial radioisotope production facility, a boiling water power reactor, and a pressurized water power reactor. In addition, even though certain gross analyses are still performed routinely on the more than 3200 environmental samples received, there has been a marked shift in emphasis from gross analyses to specific quantitative isotopic determinations. Of approximately 7200 analyses performed during the year, more than 2000 were quantitative specific isotopic analyses in which over 30 specific isotopes were identified.

1.3 Interlaboratory Quality Control (D. G. Olson)

All of the analytical chemistry laboratories at the National Reactor Testing Station are participating in a quality control study to intercompare results from the analysis of low level radioactive samples. Two planchets with deposited activity and two sets of aqueous solutions were sent to the participating laboratories for the determination of gross alpha and beta, alpha and gamma spectrometry, and radiochemical determination of ^{90}Sr.

The data in Table I show that gamma spectrometry was in control with ^{137}Cs giving the best results and ^{144}Ce giving the poorest results. Three of the laboratories were in agreement, while the fourth was 50% higher than the rest in the determination of ^{90}Sr. This was corrected on the second set of samples. Another laboratory was 50% low on the alpha-spectrometric determination which was shown to have been due to improper calibration. Similarly, the second set of data showed much better agreement on the alpha results. The standard deviation dropped from about 20% on the first aqueous test to 10% on the second.

1.4 Calibration and Quality Control of Ge(Li) Detector (R. J. Kelson)

Ge(Li) detectors are solid-state ionization devices whose efficiencies are dependent on drift depth and configuration. Consequently, it is necessary to monitor the efficiency of the crystal frequently. During 1971 a ^{226}Ra source with a constant geometry was prepared and counted periodically. The 0.242 MeV and 1.120 MeV peaks were checked for any significant change in the counting efficiency and gain drift. Over a period of six months, no significant change in the counting efficiency occurred, with the high and low values for each peak differing by no more than two standard deviations. During a period of one week, the gain shifted an average of 0.85 channel per day. This project will be continued in the future in order to assure adequate quality control of the 65 cc Ge(Li) detector used at the Health Services Laboratory.

Because of the many types of samples being analyzed, it is also necessary to recalibrate the detector for each different geometry used. These include 25-ml gas bulbs, 14.8- and 123-ml serum bottles, 42- and 47-mm air filters, and 400-gram soil samples. Known amounts of nuclides from 0.08 to 1.4 MeV were counted in each configuration, and a plot of energy versus efficiency factor was made for each container. By using these curves, the efficiency factor of any gamma ray in any of the counting configurations used can be easily determined.

TABLE I

INTERLABORATORY COMPARISON TEST

Laboratory	Alpha	Beta	^{90}Sr	^{144}Ce	^{137}Cs	^{60}Co	^{230}Th	^{239}Pu	^{244}Cm	^{241}Am
Prepared Planchet (P-1 and P-2)										
A	2.02×10^4	2.10×10^4			2.5×10^4			1.16×10^4		1.27×10^4
B	1.87×10^4	2.3×10^4			2.4×10^4					
C	2.5×10^4	2.6×10^4			2.3×10^4			1.2×10^4		1.3×10^4
D	2.11×10^4	2.92×10^4			2.47×10^4			1.10×10^4		1.01×10^4
Mean	2.13×10^4	2.48×10^4			2.42×10^4			1.13×10^4		1.19×10^4
Sigma	270	360			90			60		16
% Deviation	13	15			4			5		13
Test 1 (A-1 and B-1)										
A	3330	3860	264	955	622	555	1520	1290	1140	
B	2540	1320	385	880	650	490	810	625	650	
C	4300	2700	270	530	620	740	1600	1400	1300	
D	3357	3661	251	910	615	500	1255	1121	980	
Mean	3381	3335	292	819	627	571	1296	1109	1017	
Sigma	720	526	62	195	16	116	356	342	277	
% Deviation	21	16	21	24	3	20	27	31	27	

Continued

TABLE I (Contd.)

INTERLABORATORY COMPARISON TEST

Laboratory	Alpha	Beta	^{90}Sr	^{144}Ce	^{137}Cs	^{60}Co	^{230}Th	^{239}Pu	^{244}Cm	^{241}Am
					Test 2 (A-2 and B-2)					
A	1845	5796	244	2330	648	846	696	593	528	
B	1840	5100	250	2500	675	800	638	680	522	
C	2100	3800	280	1900	590	710	750	670	630	
D	1666	5582	239	2156	621	857	623	563	481	
Mean	1863	5069	253	2221	634	803	677	626	540	
Sigma	179	894	18	256	36	67	58	58	63	
% Deviation	10	18	7	12	6	8	9	9	12	

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Wholebody Counting (J. I. Anderson)

The rotational wholebody counter has been improved by the addition of a focusing scanning attachment to the system described in last year's report. An oval-shaped fiber glass container is used to support the patient in a position for counting. The individual is protected from the rotating detectors by a fiber glass shell so that the detectors can be made to rotate very close to the body. The result is a substantial increase in the sensitivity of the system for measuring quantities of radionuclides in the body and an even greater improvement in the capability to determine distribution of these radioactive elements by helical scanning. Spatial resolution has been improved markedly by the use of the focusing collimator and this better counting geometry.

Figure 1 is a comparison of two isometric plots obtained by helical scanning that shows radionuclide distributions in the body. Plot A shows the results from scans that were obtained by the utilization of the old counting system. The peaks for ^{137}Cs and ^{60}Co are broad and poorly resolved. Plot B was obtained by utilization of the improved counting technique. Precise positions of ^{141}Ce, ^{51}Cr, and ^{85}Sr are discernible from the highly resolved peaks from these nuclides. The levels of activity for ^{141}Ce, ^{51}Cr, and ^{85}Sr were 3, 30, and 4 μCi, respectively, and the short counting time of 16 minutes was used to obtain these results. Twenty similar plots were obtained for different locations of these nuclides in the body.

2.2 *In Vivo* Plutonium Counting (L. E. Howard)

Past experience has proved that the most likely mode for internal human exposure at the NRTS is by inhalation of insoluble forms of the nuclides. Since the transuranic nuclides are steadily increasing at this site, the capability of determining the lung burden by external counting has become necessary.

The lung counter presently being used in the Laboratory consists of two 8- by 1/4-inch NaI(Tl) detectors connected in parallel. An Alderson Rando phantom, "Herbie", was used to calibrate the lung counting system for ^{239}Pu with the assumption that the activity is uniformly distributed throughout the lungs.

The phantom was loaded with plutonium and counted in the Laboratory and then taken to Los Alamos Scientific Laboratory (LASL) for counting to compare counting efficiencies; LASL is recognized as a leader in the field of *in vivo* plutonium counting. LASL uses two 5-inch phoswich detectors which are designed for low background counting while HSL uses off-the-shelf detectors normally used for *in vivo* ^{90}Sr analysis. "Herbie" was counted in both laboratories and the results are shown in Table II.

Since the average chest-wall thickness overlying the lungs varies from about 0.5 to 4.0 cm, the transmission of the 17-keV X-ray from ^{239}Pu will vary from 60 to 0.7%. Before the activity in the human lung can be calculated, it is necessary to know the chest-wall thickness. An echoencephalscope was purchased (Hewlett-Packard Company) to make these chest-wall measurements. This instrument uses a transducer to transmit a high-frequency, low-energy pulse into the body and to receive the resultant echoes whenever a transmitted pulse encounters a boundary or interface. The received echoes are then amplified and

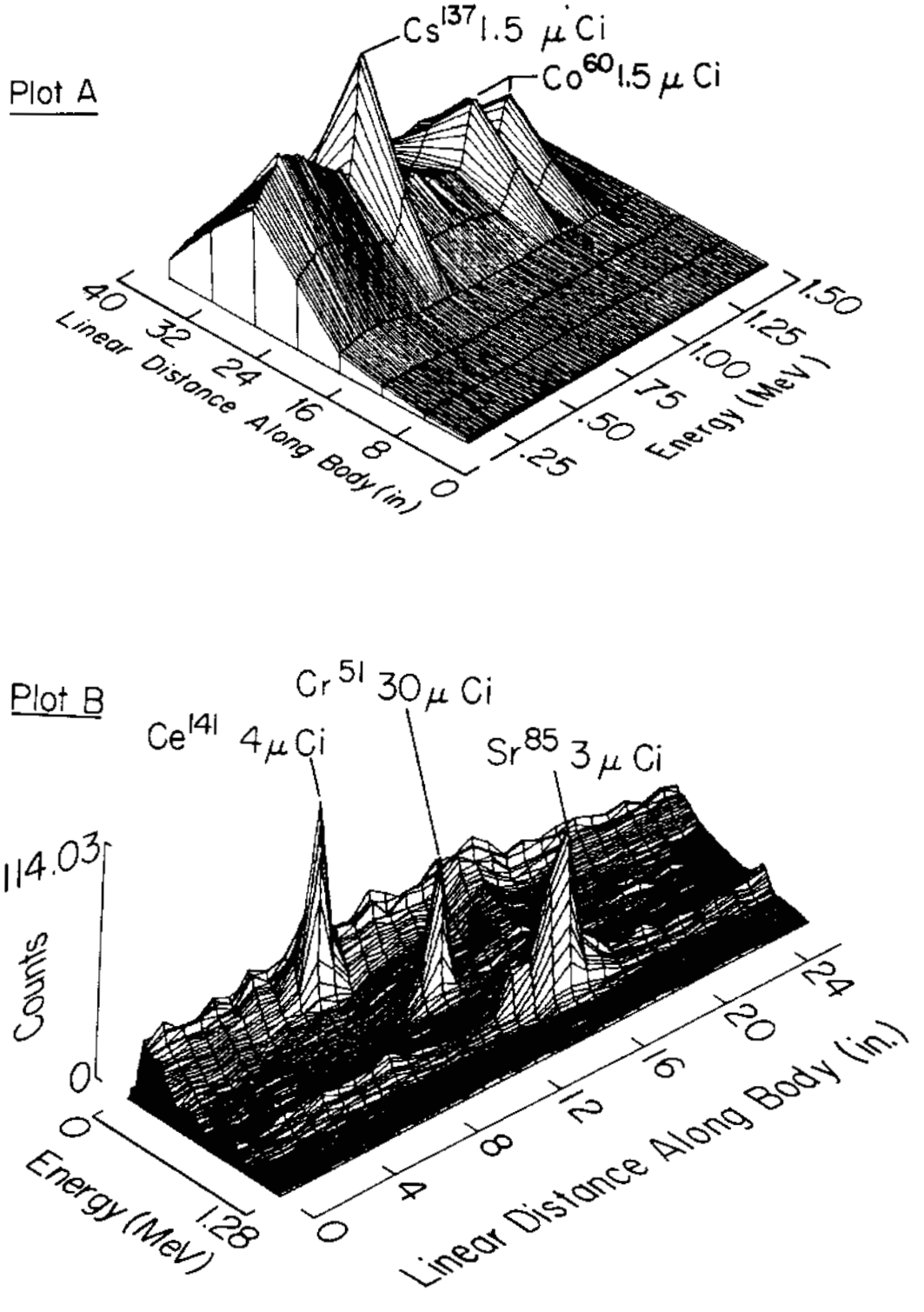

Fig. 1 Helical scans of the same individual before and after improvement of the counting system.

TABLE II

COMPARISON OF LABORATORY RESULTS

	HSL c/100 min	LASL c/100 min
Vault background	8716	1224
"Herbie's" background	11,421	1896
"Herbie" with 66.67 nCi ^{239}Pu in lungs minus "Herbie's" background	5633	2327
"Herbie" with 183.4 nCi ^{239}Pu in lungs minus "Herbie's" background	14,567	5958
"Herbie" with 216.7 nCi ^{239}Pu in lungs minus "Herbie's" background	17,402	7425

Estimated detection limit is 7.4 nCi for HSL and 5.5 nCi for LASL.

displayed so that the distance to the reflecting boundary or interface can be accurately measured. The chest-wall thickness is measured at 8 points between the ribs over each lung; all 16 points are averaged.

The calibration of the detectors is being continued by measuring a known amount of ^{238}Pu in mock lungs which have the correct density and atomic number. A study of the normal background of many individuals who have never worked with radioactivity is being made.

2.3 Analysis of Geological Samples from Test Wells at NRTS Burial Ground (J. I. Anderson, L. E. Howard)

A method was developed to analyze samples of basalt and sedimentary materials from well-drilling operations at the waste burial ground at the NRTS by computerized gamma spectrometry. More than 100 samples from 0- to 600-foot depths during drilling have been analyzed to date. The purpose of analyzing the samples was to determine the extent of migration of gamma-emitting nuclides from the burial ground toward the underlying water table. All of the spectra from these samples were extremely complex because of the large quantities of naturally occurring uranium and thorium chains, in equilibrium with their radioactive daughters, and ^{40}K. Consequently, the samples had to be counted for relatively long periods of time to obtain an acceptable detection limit for fission and activation products.

Because the spectra were complex and because the resolution of the NaI(Tl) detectors was relatively low, data reduction had to be done by fitting standard spectra either by computer or hand to spectra from the samples. The first trials to use the "peak search" computer method were not successful because all of the peaks in the spectra were not resolved. Consequently, standard spectra of ^{232}Th and daughters, ^{238}U and daughters, and

^{40}K had to be obtained and fit to the spectrum from each sample. A quality-of-fit number was determined by the computer for each sample. The number was used to indicate the degree to which the standard spectra differed from the spectrum of the sample. Peaks in the spectra that were from radionuclides other than the naturally occurring radioactive elements would render poor quality-of-fit numbers. Even though the wells were near the perimeter of the burial ground, no foreign activity was detected in any of the 114 samples analyzed. A detection limit of <0.2 d/m/g was obtained.

Activities of ^{238}U, ^{232}Th, and ^{40}K were determined for all the samples that were analyzed. Increased activity from these nuclides was found in samples that were collected near the surface of the ground and at depths where there was a predominance of sedimentary materials. Figure 2 shows the variation of activity from ^{40}K, ^{238}U, and ^{232}Th as a function of the depth of sampling from 0 to 620 feet. Data had not been obtained for the range from 320 to 480 feet at the time of this report, so the curves are not continuous. Increased activity for the three nuclides is indicated at 120, 240, and 520 feet. Results from the logs of the wells indicate the presence of sedimentary formations at the depths where peaks occur on these plots. The curves do not parallel each other at depths greater than 540 feet. Peaks occur at approximately the same depth for ^{238}U and ^{40}K, but the distribution of ^{232}Th is different over this range of depth.

2.4 Software for the 50/50 Analyzer (D. G. Olson)

Computer programs have been written for the 50/50 spectrometer which enhance the data reduction capability in addition to reducing analysis time. Included in the package are subroutines for printing, totalizing, transferring, data changing, smoothing, and plotting. The heart of the program is the "find" routine which automatically locates photopeaks and evaluates preselected gamma energies to determine their detection limits. When a peak is found, a statistical test is applied to see if the peak integral exceeds the detection limit. If the detection limit is exceeded or if a preselected energy is located, the gamma energy, channel number, peak integral, detection limit, counts per minute, and standard deviation are printed as shown in Table III. Thus, in one scan of the spectrum, every peak which exceeds the detection limit and as many as 12 preselected nuclides which do not exceed the detection limit are determined. A typical gamma spectrum is shown in Figure 3 and the data from the peak-find program are printed as Table III. Note that every peak shown on the plot was found by the computer program. In addition, two peaks at energies 364 and 810 keV were requested by the analyst and found to be below the detection limit. The regions of these energies are marked on the plot showing that only background counts are present in these areas. The peak-find program is looped so that it will function automatically when coupled with a sample changer.

The value of this program to the chemist is that many requestors want to know about certain nuclides plus every other nuclide that can be detected. The peak-find program solves this difficult problem.

2.5 Liquid Scintillation Techniques (R. B. Randolph)

A procedure has been developed for the simultaneous determination of ^{90}Sr and ^{89}Sr by liquid scintillation. Work on the procedure is largely complete and the manuscript for publication has been started. The detection limit for ^{90}Sr is 1 pCi for ratios of ^{89}Sr:^{90}Sr between 0.1 and 10. The detection limit for ^{89}Sr is 1 pCi for any ratio of ^{89}Sr:^{90}Sr.

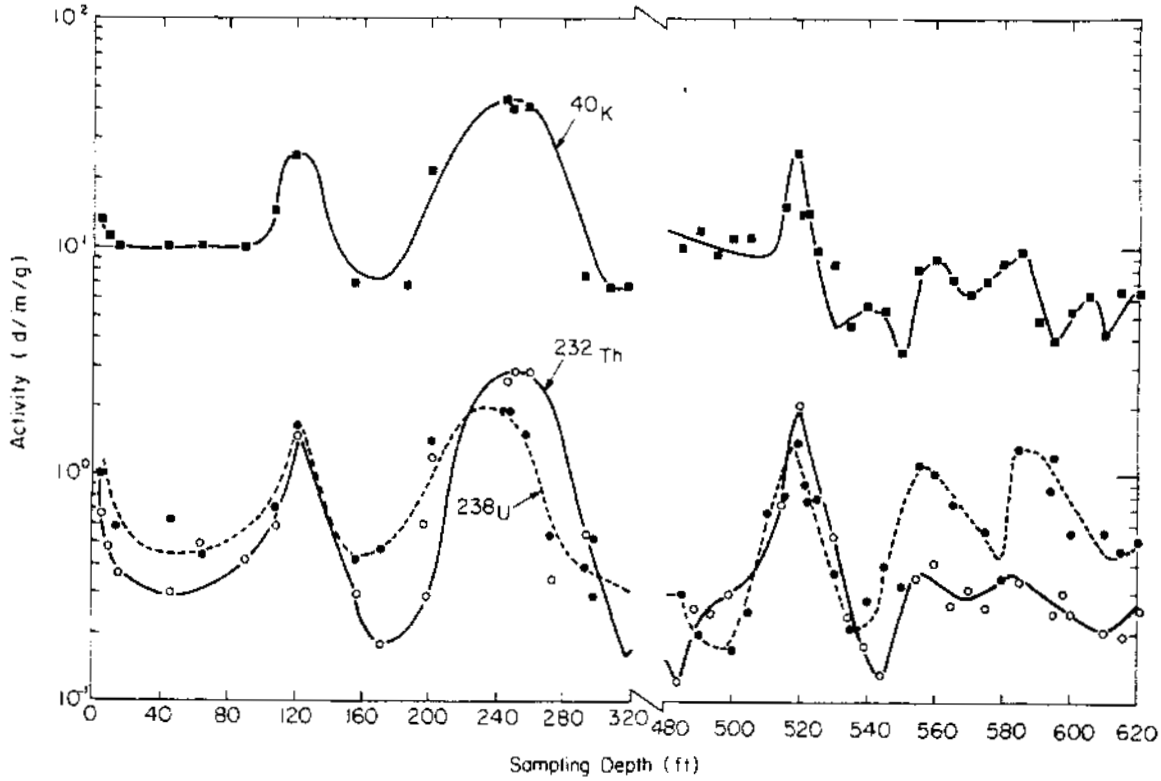

Fig. 2 The variations of ^{40}K, ^{238}U, and ^{232}Th in soil samples from test well 88.

Work has begun to develop a gross beta method by liquid scintillation which would be more accurate and reliable than the present method of counting an evaporated sample with a proportional counter. It is anticipated that variable solids and beta energy will have little effect on the liquid scintillation method in contrast to the conventional method. This may help fill the need for a gross beta method to detect those beta emitters, ie, ^{3}H, ^{14}C, ^{45}Ca, ^{55}Fe, ^{147}Pm, ^{241}Pu, and ^{63}Ni, which are detected not at all or with very low efficiency in conventional beta counters.

2.6 Determination of ^{129}I in Air, Water, and Vegetation (C. P. Willis)

Iodine-129 is a long-lived, high-yield fission product of increasing importance in biological samples. Because of the 1.6 x 10^7-year half-life and the very low energy of the beta and gammas produced, the detection limit is much higher than is desirable. A procedure has been developed for lowering the detection limit by converting the ^{129}I to ^{130}I by neutron activation. Iodine-130 has a 12-hour half-life and three gamma energies which are easily measured. Samples are decomposed, and the iodine is collected on activated charcoal. The charcoal is then irradiated in the ETR and decomposed with acids. The iodine is then extracted from the decomposition products, and the ^{130}I is measured with a gamma spectrometer. The detection limit for ^{129}I by this procedure is about 1 ng.

2.7 Determination of the Actinide Elements in Soil (C. W. Sill, K. W. Puphal, F. D. Hindman)

A method was developed for the analysis of all actinides in 10 g of soil. The actinides are precipitated on barium sulfate which is dissolved in molten aluminum nitrate nonahydrate and nitric acid. The aluminum nitrate is adjusted to 2.2M, and protactinium,

TABLE III

COMPUTER READOUT OF A TYPICAL GAMMA SPECTRUM

FIND

*BACKGROUND SUBTRACTED

*TIME = Ø.77ØØØØ1 + Ø1 DAY OF YEAR: 34

*SUMMATION: Ø.273Ø28Ø + Ø6

* KEV	CHAN	COUNTS	DL	C/M	DEV
81.99	213Ø	1365	166.11	177.29	11.69
134.9Ø	2183	1Ø233	146.57	1328.94	16.15
#364.Ø2	244Ø	6	11Ø.72	.78	7.Ø7
66Ø.53	27Ø9	12118	77.54	1573.79	15.11
695.78	2744	18Ø	75.86	23.33	5.1Ø
#81Ø.Ø5	291Ø	-26	76.98	-3.42	4.82
1172.65	3221	5764	55.22	748.64	1Ø.45
1332.43	3381	4888	39.96	634.85	9.41

#NUCLIDES SOUGHT BY ANALYST BELOW DETECTION LIMIT

KEV = ENERGY

DL = DETECTION LIMIT

DEV = STANDARD DEVIATION

CHAN = CHANNEL

uranium, thorium, neptunium, and plutonium are extracted into a quaternary amine. The last two actinides are more completely extracted in the presence of high concentrations of nitrous acid. The nitric acid in the aqueous phase is neutralized with acid-deficient aluminum nitrate, and americium, curium, and californium are extracted into a second portion of the quaternary amine. Selective back extractions separate the actinides into three groups: (a) the tervalent elements, americium, curium, and californium; (b) thorium (which is nearly specific); and (c) protactinium, uranium, neptunium, and plutonium. Group (a) is precipitated out on cerium hydroxide and mounted for counting, while groups (b) and (c)

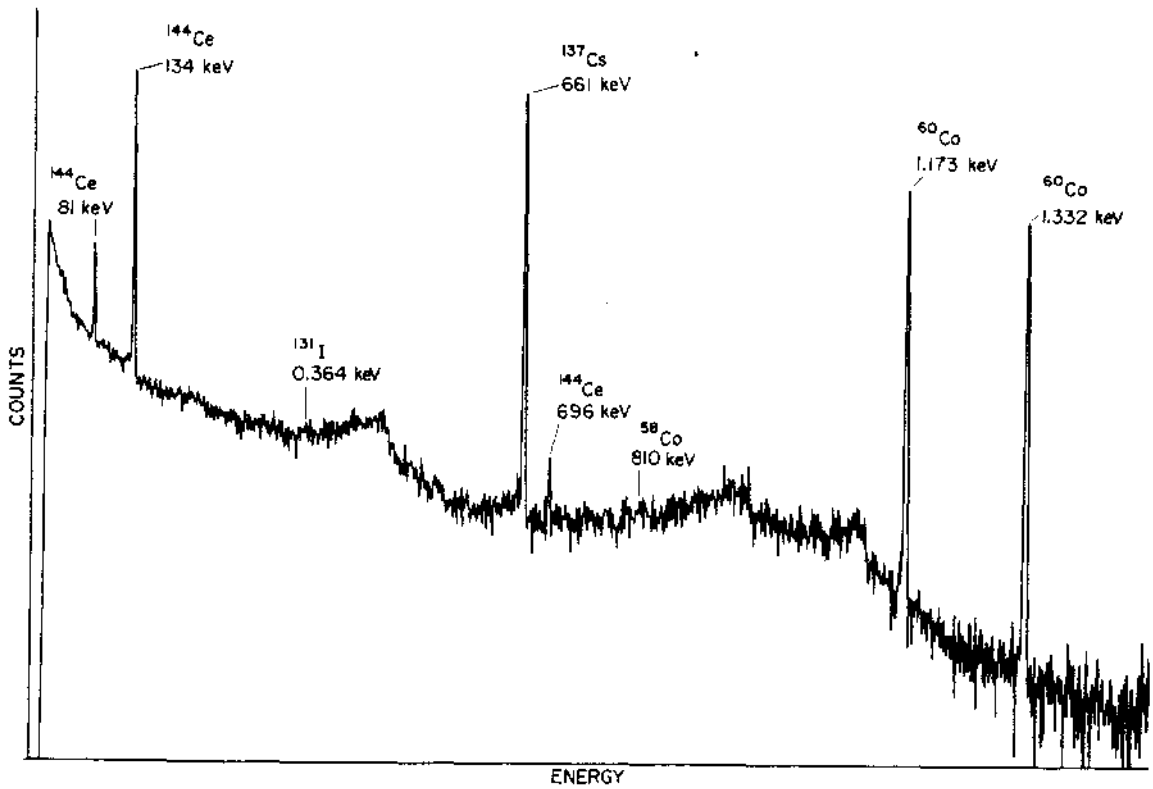

Fig. 3 Typical gamma spectrum.

are electrodeposited. Counting rates and isotope identification are determined on each group by alpha spectroscopy.

2.8 Gross Alpha Determination in Bone (K. W. Puphal)

A method is being developed for the determination of the alpha-emitting nuclides in bone. After the green bone is ashed in a muffle furnace at approximately 1000°C, a 10-g portion is dissolved in nitric acid and made 2.2M in aluminum nitrate. A liquid-liquid extraction with a quaternary amine separates thorium (approximately 98%), uranium (approximately 98%), neptunium (approximately 95%), and plutonium (approximately 98%). An hydrochloric acid back extraction nearly specifically removes thorium, the others being removed with perchloric acid--oxalic acid. The nitric acid in the extracted aqueous phase is neutralized with acid-deficient aluminum nitrate and is contacted with a second portion of quaternary amine extracting americium (approximately 98%), other tervalent actinides, and lanthanides, which are subsequently stripped with 8M nitric acid. Each fraction is electrodeposited to determine counting rates and isotope identification by alpha spectroscopy.

2.9 Electrodeposition Procedure for High Resolution Alpha Spectroscopy (K. W. Puphal, D. R. Olsen, G. J. McNabb)

A method has been developed for electrodepositing various alpha-emitting nuclides, singly or in combination, onto a stainless steel cathode. The nuclides as standard solutions or samples are taken to dryness with 100 mg of sodium acid sulfate and deposited as hydroxides to better than 98% in 50 minutes from an ammonium chloride--ammonium oxalate electrolyte. The use of a Teflon insert in the Teflon O-ring seal in the deposition cell

decreased the deposited area from about 480 to about 260 mm^2, resulting in improved sensitivity and reliability with the 450 mm^2 solid-state detector.

2.10 Uniform Electrodeposition Research (G. J. McNabb)

A study was begun to determine the conditions necessary for the attainment of a uniform electrodeposition. Deposited plates were autoradiographed to determine the uniformity of the deposited activity. Cylindrical gauze, single wire, spiral, flat gauze, and propeller electrodes were studied as possible anode configurations. The flat gauze electrode and the propeller electrode showed little promise since the gas bubbles which collected below them prevented electrical conduction. An electrode which had a large fluid friction, such as the cylindrical gauze anode, was very sensitive to stirring rates. While some stirring is required, it was found that even moderate amounts of stirring resulted in a "doughnut" conformation of the activity at the periphery with less activity toward the center of the electrodeposited area. The single linear wire anode gave uniform deposits over the majority of the deposited area, but it left a scallop at the periphery where little was deposited. Although the electrodeposition apparatus has a small amount of alternating current ripple, the uniformity did not noticeably increase when direct current from a storage battery was used. It was found that for good uniformity some stirring is necessary and that the anode does play a role in achieving both uniform and quantitative depositions. Although the study is not complete, it appears that 30 rpm of a spiral anode will be recommended for the procedure.

2.11 Rapid Decomposition of Diethylenetriaminepentaacetic Acid (R. L. Williams)

A method has been developed that substantially reduces the time required to decompose the diethylenetriaminepentaacetic acid (DTPA) which is used in the dissolution of barium sulfate. Normal wet-ashing methods with nitric and perchloric acids are time consuming and usually require repeated additions of the oxidizing acids. In the proposed method, the liquid is evaporated in the presence of sulfuric acid and sodium sulfate, heated to a high temperature over a blast burner, and then subjected to a wet-ashing treatment with nitric and perchloric acids. The sodium sulfate prevents the actinides from being converted to refractory oxides, and the high temperature heating speeds up the otherwise slow wet-ashing decomposition of DTPA.

2.13 Sequential Radiochemical Determination of ^{226}Ra, ^{228}Ra, ^{227}Ac, and Thorium Isotopes in Environmental and Process Waste Samples (D. R. Percival, D. B. Martin)

A procedure for the sequential determination of ^{226}Ra, ^{228}Ra, ^{227}Ac, and thorium isotopes was finalized. A manuscript was completed which will be submitted for publication.

2.14 Large Volume Sampler-Concentrator for Nuclear Facility Effluents and Environmental Water Monitoring (D. R. Percival, D. B. Martin)

The quantitative determination of fission and activation products at concentrations $\leq 10^{-10}$ μCi/ml in surface and ground waters and in liquid wastes from nuclear power plants requires separation and concentration of the radionuclides from very large samples. Methods which have been used for this purpose were evaluated in relation to principle, capacity, cost, etc. An evaporation method for up to 2000 liters of water containing $\leq$500 ppm of dissolved solids was chosen tentatively as the one which might best meet all requirements. Preliminary studies were begun on this and alternative methods with the intention of having an operational sampler-concentrator by mid-1972.

2.15 A Total Decomposition Method for the Determination of ^{90}Sr in Soils (D. B. Martin)

A total sample decomposition procedure for the determination of ^{90}Sr in up to 10 g of soil was developed. The procedure utilizes a potassium fluoride and a mixed sodium-potassium pyrosulfate fusion for total sample decomposition, lead and/or strontium sulfate precipitation for ^{90}Sr recovery, and a specific bis(2-ethylhexyl)phosphoric acid extraction of the ^{90}Y daughter from a diethylenetriaminepentaacetic acid solution. With this procedure, less than 0.01 pCi of ^{90}Sr can be detected in 10 g of soil with an overall recovery of 90%. This procedure will also be applied to water samples.

2.16 The Determination of ^{90}Sr in Soils with Acid Leach (S. L. Martin)

A leaching procedure for ^{90}Sr in soils is being developed to shorten the time required for analysis. The procedure involves dissolution of 10 g of soil in hydrofluoric acid and precipitation of strontium with fuming nitric acid.

In large volume water samples, it has been observed that the ^{85}Sr recovery is higher by approximately 10% when the water is allowed to stand overnight after addition of phosphoric acid to precipitate out the strontium.

2.17 Determination of ^{210}Po in Environmental Samples (R. P. Bernabee)

A procedure has been developed for the determination of ^{210}Po in environmental samples. The method employs total decomposition of up to 10 g of ores and soils via fluoride and pyrosulfate fusions. Strong oxidizing agents are used in conjunction with the fusions to prevent losses due to volatilization and plating on the platinum vessel. Air dust filters (4 inch) and up to 15 g of organics are treated by wet-ashing with nitric, sulfuric, and perchloric acids followed by a sodium pyrosulfate fusion.

An extensive study of the volatility of ^{210}Po under conditions most likely to occur during analytical sample treatment has been carried out. In all cases where a reducing agent was present, significant losses of ^{210}Po resulted. Conversely, in all cases where an oxidizing agent was used, complete recovery was obtained.

Separation of ^{210}Po from interfering elements is achieved by liquid-liquid extraction with trilaurylamine in xylene. The small concentrations of acid and amine used make for an efficient separation from other alpha emitters. Back extraction is carried out with 5% perchloric acid. The determination of ^{210}Po can then be made either by spontaneous deposition on silver or by coprecipitation with tellurium metal.

2.18 Instability of ^{210}Po Tracer in Acids (R. P. Bernabee)

The instability of ^{210}Po tracer in 1M nitric acid over a period of 30 days in glass led to an investigation of its behavior in various acids and complexing agents. The only combination yielding reproducible results over a period of six months or more is a 20% sulfuric acid--cerium(IV) solution after a pyrosulfate fusion.

2.19 Fluorometric Determination of Natural Uranium in Soil (R. P. Bernabee)

A procedure for the determination of ^{nat}U in soil has been developed using a high temperature leach in an acid digestion bomb. Samples of up to 1 g of soil can be analyzed yielding an increase of a factor of four in sensitivity over the sulfate fusion process previously used. The sample is digested in 48% hydrofluoric acid and nitric acid for two hours at 135°C. Separation of ^{nat}U is achieved by liquid-liquid extraction from an acid-deficient aluminum nitrate--tetrapropyl ammonium nitrate solution with hexane. Final determination is made by fusing an aliquot of the organic extract with lithium fluoride--sodium fluoride and measuring the fluorescence with a fluorophotometer.

2.20 A Sampler for Atmospheric Sulfur Dioxide and Nitrogen Dioxide (S. M. Lombard, T. D. Filer, G. E. Grothaus)

A sampler for the simultaneous determination of atmospheric sulfur dioxide and nitrogen dioxide concentrations at the NRTS was designed and tested. The analytical procedures prescribed by the Environmental Protection Agency are to be used in the determinations. The sampler was designed to operate continuously under any climatic conditions anticipated at the NRTS. Absorber tubes will be prepared by the Analytical Chemistry Branch for replacement in the samplers three times a week, and weekly composite samples will be analyzed. Five samplers have been constructed and will be placed in operation in early 1972.

2.21 Fluorometric Determination of Submicrogram Quantities of Tin (T. D. Filer)

A fluorometric procedure for the determination of tin using 3,4′, 7-trihydroxyflavone has been developed that is much more sensitive than other common methods. After decomposition of the sample by a pyrosulfate fusion, the tin is extracted as the iodide into toluene from a sulfuric acid solution. The fluorescence of the tin(IV)--3,4′,7-trihydroxyflavone complex is measured in a sulfate buffer solution. The method has a detection limit of 0.007 μg, a precision to about 2% on 1 μg, and excellent tolerance to most common elements, antimony and tantalum being the only serious interferences.

2.22 Separation of Tervalent Lanthanides from Tervalent Actinides (T. D. Filer)

Methods are being investigated for the separation of the tervalent actinides from the tervalent lanthanides. The separation of the thiocyanate complexes of the lanthanides and actinides on an anion exchange column has been the most promising approach thus far.

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SECTION II APPENDIX

DETECTION LIMITS FOR ANALYTICAL PROCEDURES

RADIOACTIVE ISOTOPES

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method or Instrument	Detection Limit
Alpha (gross)	Water	100 ml	60 min	Scintillation	2×10^{-9} µCi/ml
	Milk	100 ml	30 min	Scintillation	1×10^{-8} µCi/ml
	Metricel Filter	All	60 min	Scintillation	2×10^{-7} µCi/filter
	Air	5000 m^3	1000 min	Alpha Spectrometry	5 aCi/m^3
Beta (gross)	Water	250 ml	20 min	Low Bkgd Counter	5×10^{-9} µCi/ml
	Water	100 ml	20 min	Low Bkgd Counter	1×10^{-8} µCi/ml
	Water	5 ml	20 min	Low Bkgd Counter	2.4×10^{-7} µCi/ml
	Urine	5 ml	20 min	Low Bkgd Counter	4.4×10^{-7} µCi/ml
	Milk	100 ml	20 min	Low Bkgd Counter	2.4×10^{-8} µCi/ml
	Metricel or Carbon	All	20 min	Low Bkgd Counter	1×10^{-6} µCi/filter
^{60}Co	Water	75 ml	5 min	3 Inch Well Crystal	5×10^{-7} µCi/ml
	Human Body	All	10 min	Gamma Spectrometer	0.002 Ci
^{51}Cr	Water	75 ml	5 min	3 Inch Well Crystal	5×10^{-6} µCi/ml
^{137}Cs	Water	75 ml	5 min	3 Inch Well Crystal	6.7×10^{-7} µCi/ml
	Milk	3 liters	60 min	Gamma Spectrometer	30 pCi/l
	Milk	1000 ml	30 min	5 Inch Well Crystal	3×10^{-8} µCi/ml
	Human Body	All	10 min	Gamma Spectrometer	0.002 Ci
F. P. (gross)	Urine	75 ml	5 min	3 Inch Well Crystal	2×10^{-6} µCi/ml
^{131}I	Milk	3 liters	60 min	Gamma Spectrometer	10 pCi/l
	Milk	1000 ml	30 min	5 Inch Well Crystal	2×10^{-8} µCi/ml
	Water	75 ml	5 min	3 Inch Well Crystal	6.7×10^{-7} µCi/ml
	Water	1000 ml	30 min	5 Inch Well Crystal	3×10^{-8} µCi/ml

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method or Instrument	Detection Limit
^{131}I	Rabbit Thyroid	225 mg	5 min	Small Well Crystal	1×10^{-4} μCi/g
Gamma	Filters	All	5 min	Small Well Crystal	3×10^{-5} μCi/total
^{131}I	Small Carbon Cartridge	All	1 min	Small Well Crystal	5×10^{-5} μCi/sample
	Human Thyroid	All	10 min	Gamma Spectrometer	1×10^{-2} pCi
^{231}Pa	Water	100 ml	30 min	Scintillation	2×10^{-9} μCi/ml
	Solids	0.5 g	30 min	Scintillation	2×10^{-6} μCi/g
^{210}Pb	Air	100 m^3	30 min	Beta Counter	2×10^{-8} μCi/m^3
	Water	500 ml		Beta Counter	3×10^{-9} μCi/ml
	Solids	1 g		Beta Counter	2×10^{-6} μCi/g
^{210}Po	Water	100 ml	60 min	Scintillation	3×10^{-9} μCi/ml
	Soil	5 g	60 min	Scintillation	8×10^{-8} μCi/g
	Veg.	5 g	60 min	Scintillation	5×10^{-8} μCi/g
	Filters	10^6 ml	60 min	Scintillation	3×10^{-13} μCi/ml
^{239}Pu	Urine	1000 ml	60 min	Scintillation	2×10^{-10} μCi/ml
	Water	1000 ml	60 min	Scintillation	2×10^{-10} μCi/ml
	Soil	10 g	1000 min	Alpha Spectrometry	0.005 d/m/g
	Air	330 m^3	10 min	Scintillation	6×10^{-15} μCi/cc
	Human Lung	All	100 min	Gamma Spectrometer	13 nCi
^{226}Ra	Water	500 ml	60 min	Emanation	3×10^{-10} μCi/ml
	Solids	5 g	60 min	Emanation	3×10^{-8} μCi/g
	Air	100 m^3	60 min	Emanation	1×10^{-15} μCi/cc
^{228}Ra	Water	500 ml	50 min	Low Bkgd Counter	5×10^{-9} μCi/ml
	Solids	5 g	50 min	Low Bkgd Counter	5×10^{-7} μCi/g
	Air	100 m^3	50 min	Low Bkgd Counter	3×10^{-14} μCi/cc

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method or Instrument	Detection Limit
^{222}Rn	Air	6 liters	60 min	Emanation	0.05 pCi/l
^{90}Sr	Urine	75 ml	20 min	Low Bkgd Counter	1×10^{-8} µCi/ml
	Milk	1000 ml	20 min	Low Bkgd Counter	1×10^{-9} µCi/ml
	Bone Ash	20 g	20 min	Low Bkgd Counter	5×10^{-8} µCi/g
	Bone Ash	5 g	20 min	Low Bkgd Counter	2×10^{-8} µCi/g
	Water	400 ml	20 min	Low Bkgd Counter	3×10^{-9} µCi/ml
	Water	200 ml	20 min	Low Bkgd Counter	5×10^{-9} µCi/ml
	Soil	10 g	20 min	Low Bkgd Counter	1×10^{-7} µCi/g
	Human Body	All	10 min	Gamma Spectrometer	0.03 µCi
	Veg. (Dry)	25 g	30 min	Low Bkgd Counter	6×10^{-8} µCi/g
^{230}Th	Water	500 ml	60 min	Scintillation	1×10^{-9} µCi/ml
	Solids	5 g	60 min	Scintillation	1×10^{-7} µCi/g
	Air	100 m^3	60 min	Scintillation	6×10^{-15} µCi/cc
Tritium	Water	10 ml	20 min	Liquid Scintillation	2 pCi/ml
	Urine	3 ml	20 min	Liquid Scintillation	15 pCi/ml
Uranium	Human Lungs	All	40 min	Gamma Spectrometer	30 mg
			STABLE ELEMENTS		
Arsenic	Air	100 m^3		Colorimetric	1×10^{-8} g/m^3
	Urine or Water	500 ml		Colorimetric	2×10^{-6} g/l
Beryllium	Air	100 m^3		Fluorometric	5×10^{-12} g/m^3
	Air	20 liters		Fluorometric	3×10^{-8} g/m^3
	Bone Ash	10 g		Fluorometric	5×10^{-9} %
	Urine or Water	1 liter		Fluorometric	5×10^{-8} g/l
	Solids	1 g		Fluorometric	5×10^{-8} %
Cr(VI)	Water	20 ml		Colorimetric	10 µg/l
Cr (Total)	Water	20 ml		Colorimetric	10 µg/l
Lead	Air	100 m^3		Colorimetric	1×10^{-8} g/m^3

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method of Instrument	Detection Limit
Lead	Urine or Water	500 ml		Colorimetric	2×10^{-6} g/l
	Urine or Water	100 ml		Colorimetric	1×10^{-5} g/l
Mercury	Air	100 m^3		Colorimetric	1×10^{-8} g/m^3
	Urine or Water	500 ml		Colorimetric	2×10^{-6} g/l
Antimony	Water	1 liter		Fluorometric	0.2 µg/l
Tin	Water	25 ml		Fluorometric	.03 µg/l
Thorium	Air	100 m^3		Fluorometric	1×10^{-10} g/m^3
	Air	20 liters		Fluorometric	5×10^{-7} g/m^3
	Bone Ash	1 g		Fluorometric	1×10^{-6} %
	Urine or Water	1 liter		Fluorometric	1×10^{-10} g/l
	Solids	1 g		Fluorometric	1×10^{-6} %
Zirconium	Water	25 ml		Fluorometric	0.08 µg/l
			GAMMA SPECTROMETRY		
			Soil		
^{144}Ce	Soil	50 g	1000 min	65cc GeLi	0.3 pCi/g
^{60}Co	Soil	50 g	1000 min	65cc GeLi	0.05 pCi/g
^{51}Cr	Soil	50 g	1000 min	65cc GeLi	0.4 pCi/g
^{134}Cs	Soil	50 g	1000 min	65cc GeLi	0.05 pCi/g
^{137}Cs	Soil	50 g	1000 min	65cc GeLi	0.05 pCi/g
^{131}I	Soil	50 g	1000 min	65cc GeLi	0.05 pCi/g
^{95}Nb	Soil	50 g	1000 min	65cc GeLi	0.04 pCi/g
^{106}Rh (^{106}Ru)	Soil	50 g	1000 min	65cc GeLi	0.08 pCi/g
^{65}Zn	Soil	50 g	1000 min	65cc GeLi	0.09 pCi/g
^{95}Zr	Soil	50 g	1000 min	65cc GeLi	0.08 pCi/g

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method or Instrument	Detection Limit
			Water		
^{228}Ac	H_2O	400 ml	100 min	65cc GeLi	0.2 pCi/ml
^{110M}Ag	H_2O	400 ml	100 min	65cc GeLi	0.05 pCi/ml
^{140}Ba	H_2O	400 ml	100 min	65cc GeLi	0.1 pCi/ml
^{212}Bi	H_2O	400 ml	100 min	65cc GeLi	0.5 pCi/ml
^{214}Bi	H_2O	400 ml	100 min	65cc GeLi	0.06 pCi/ml
^{141}Ce	H_2O	400 ml	100 min	65cc GeLi	0.05 pCi/ml
^{143}Ce	H_2O	400 ml	100 min	65cc GeLi	0.07 pCi/ml
^{144}Ce	H_2O	400 ml	100 min	65cc GeLi	0.2 pCi/ml
^{57}Co	H_2O	400 ml	100 min	65cc GeLi	0.02 pCi/ml
^{58}Co	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{60}Co	H_2O	400 ml	100 min	65cc GeLi	0.4 pCi/ml
^{51}Cr	H_2O	400 ml	100 min	65cc GeLi	0.3 pCi/ml
^{134}Cs	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{137}Cs	H_2O	400 ml	100 min	65cc GeLi	0.04 pCi/ml
^{138}Cs	H_2O	400 ml	100 min	65cc GeLi	0.6 pCi/ml
^{152}Eu	H_2O	400 ml	100 min	65cc GeLi	0.1 pCi/ml
^{59}Fe	H_2O	400 ml	100 min	65cc GeLi	0.7 pCi/ml
^{203}Hg	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{131}I	H_2O	400 ml	100 min	65cc GeLi	0.04 pCi/ml
^{132}I	H_2O	400 ml	100 min	65cc GeLi	0.05 pCi/ml
^{133}I	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{40}K	H_2O	400 ml	100 min	65cc GeLi	0.4 pCi/ml
^{85}Kr	H_2O	20 ml	100 min	65cc GeLi	2.5 pCi/ml
^{140}La	H_2O	400 ml	100 min	65cc GeLi	0.4 pCi/ml
^{54}Mn	H_2O	400 ml	100 min	65cc GeLi	0.3 pCi/ml
^{99}Mo	H_2O	400 ml	100 min	65cc GeLi	0.3 pCi/ml
^{22}Na	H_2O	400 ml	100 min	65cc GeLi	0.4 pCi/ml

Nuclide	Sample Material	Size of Sample	Counting Time	Detection Method or Instrument	Detection Limit
^{95}Nb	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{239}Np	H_2O	400 ml	100 min	65cc GeLi	0.07 pCi/ml
^{212}Pb	H_2O	400 ml	100 min	65cc GeLi	0.06 pCi/ml
^{144}Pr	H_2O	400 ml	100 min	65cc GeLi	2.0 pCi/ml
^{105}Rh	H_2O	400 ml	100 min	65cc GeLi	0.2 pCi/ml
^{103}Ru	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{106}Ru	H_2O	400 ml	100 min	65cc GeLi	0.06 pCi/ml
^{124}Sb	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{125}Sb	H_2O	400 ml	100 min	65cc GeLi	0.3 pCi/ml
^{75}Se	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{182}Ta	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{99M}Tc	H_2O	400 ml	100 min	65cc GeLi	0.02 pCi/ml
^{132}Te	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{208}Tl	H_2O	400 ml	100 min	65cc GeLi	0.03 pCi/ml
^{133}Xe	H_2O	400 ml	100 min	65cc GeLi	0.04 pCi/ml
^{65}Zn	H_2O	400 ml	100 min	65cc GeLi	0.07 pCi/ml
^{95}Zr	H_2O	400 ml	100 min	65cc GeLi	0.06 pCi/ml
			Air Filter		
^{131}I	Air Filter	2 Inch	100 min	65cc GeLi	4 pCi/filter

The list of nuclides which are detectable by gamma spectrometry is incomplete. Only the nuclides which are frequently encountered have been included.

Inert Pollutants in the Atmosphere

SO_2	Air	300 liters	Colorimetric	25 $\mu g/m^3$
NO_2	Air	300 liters	Colorimetric	20 $\mu g/m^3$

III. DOSIMETRY BRANCH
(F. V. Cipperley)

The Dosimetry Branch provides complete dosimetry service to the operating and construction contractors at the National Reactor Testing Station (NRTS). The major objectives of the Branch are to supply personnel radiation dosimetry service, maintain complete records of exposure doses, provide consulting and support service to the contractors regarding dosimetry problems, and perform research aimed at improvement of monitoring devices and systems in order to perform these duties more efficiently.

1. OPERATIONAL DOSIMETRY ACTIVITIES

1.1 Summary of External Radiation Exposure Statistics

The Dosimetry Branch provided personnel dosimetry coverage for more than 7700 regularly assigned NRTS persons during 1971. Results show that 1971 was the lowest radiation-exposure year in the history of the NRTS since full-scale operation was achieved. The total recorded sitewide accumulated wholebody exposure for the year was 1180 rem. This is an average of 168 mrem per person monitored as compared to the current 10-year average of 283 mrem.

The exposure data show that more than 90% of the persons monitored accumulated less than 500 mrem, the level at which monitoring is mandatory; less than 0.5% exceeded 3.0 rem, the recommended radiation protection guide (RPG) for a calendar quarter; and no one accumulated as much as 5.0 rem, the recommended RPG for a calendar year.

During the year the Branch processed 43,985 regularly assigned beta-gamma dosimeters, provided special processing of 1279 regularly assigned dosimeters at the request of the contractors' health physicists, and processed 62,198 other nonroutine items including nearly 18,000 temporary dosimeters for transient personnel. A total of 107,462 dosimeters of various types was processed during the year.

1.2 Summary of Internal Radiation Exposure Statistics

Results obtained by the Analytical Chemistry Branch and the Medical Department of 114 urinalyses and 1317 *in vivo* measurements on humans were recorded and tabulated. Although some statistically significant activities were found, none were physiologically significant and all were well below reportable levels.

1.3 Offsite Coverage

In line with Atomic Energy Commission Policy on Intra-Agency assistance to lower overall costs, provision for dosimetric services to several offsite AEC-connected groups was continued in 1971. Personnel dosimetry coverage was provided for employees of the Nuclear Rocket Development Station in Nevada; Sandia Laboratories at Livermore; Region IV, Division of Compliance, Denver; and the Radiological Assistance Team, AEC Headquarters. This coverage is accomplished through the use of thermoluminescent dosimeters, serviced on an annual basis unless some unusual circumstance warrants a more frequent processing.

1.4 Program Improvements

A proportional controller was obtained and installed on one of the low-temperature annealing ovens. Tests show that a precise temperature of 100°C ± 1°C can be maintained. This is of importance in annealing the TLD crystals.

The calibration facility at CF-638 (see Figures 4 and 5) is divided into four sections, a radiation-free control area, a low-level calibration room for the automatic radium calibrator, a medium-level room for generating filtered X-rays or K-fluorescent monoenergetic X-rays, and a high-level calibration room utilizing a 200-curie ^{60}Co gamma-ray camera. The safety features of the facility have been improved and updated to assure against accidental exposure to operating personnel. The high-level calibration room door has been interlocked in series with the door leading into the X-ray calibration room. Therefore, entry into either room while the 200-curie ^{60}Co source is extended will automatically retract the source. A separate gamma-ray detection system was also installed in the same room with the ^{60}Co source which activates a flashing red light at the outside door as well as in the room when the source is extended. Dose rate measurements have been made of the various sources used in the building and procedures written to allow emergency entry into the calibration facility without significant personnel exposure.

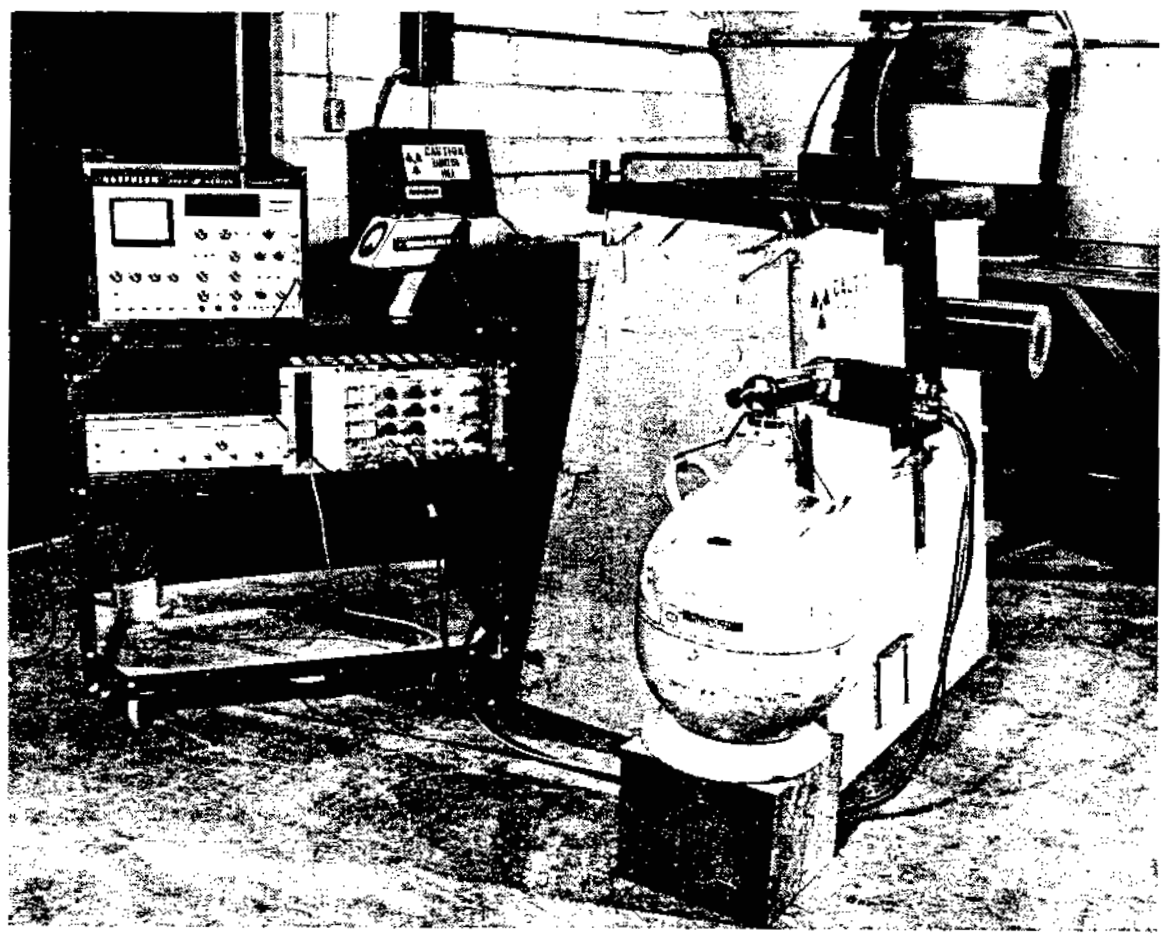

Fig. 4 X-ray calibration facility.

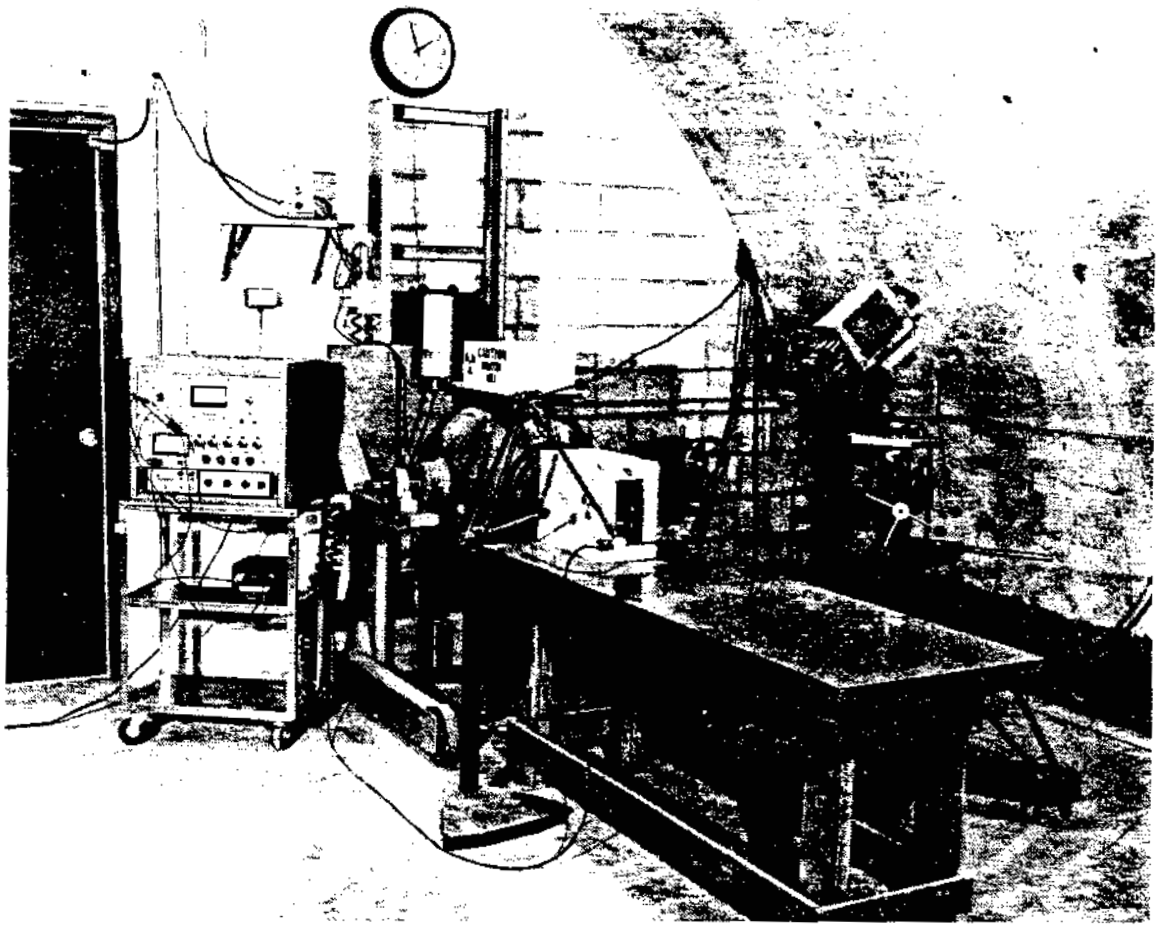

Fig. 5 High-level calibration facility.

A lead-brick collimator has been built to allow standardized use of the 200-curie ^{60}Co irradiator. A charged-particle-equilibrium lucite sheet has been installed so that all high-level calibration exposures are performed on a true rad basis. The unit has been calibrated and standardized at a dose rate of 1000 R/hr.

In conjunction with the Environmental Branch, both onsite and offsite environmental radiation measuring programs were redesigned. In light of the changing requirements imposed upon the AEC, the program was modified to provide more pertinent data. The total number of individual monitoring locations was reduced and the number of dosimeters at each location was increased from one to five in order to provide more statistically significant information.

Protective covers are now being used with the Teflon disc TL dosimeters used for NRTS personnel coverage. The covers are made of aluminized Mylar and snap into the dosimeter retainers on each side of the Teflon discs. These covers protect the discs from dust, dirt, and excessive exposure to light.

The visitor badging program at EBR-II has been converted from film to TLD. The new procedure calls for a visitor to wear both a TLD badge and a pencil dosimeter. An evaluation

of a badge is made only if the pencil dosimeter indicates an exposure. The experience of this area shows that the system works well. The conversion of other areas will be completed early in 1972.

2. SPECIAL PROBLEM DOSIMETRY

The Dosimetry Branch has developed methods, devices, and application of materials that enable accurate gamma exposure measurements from 0.5 mR through 10^8R and neutron dose calculations at five energy levels. Various thermoluminescent and radiophotoluminescent (RPL) materials, as well as activation foils, radiachromic dyes, and dosimetric films, are utilized to support the AEC contractors in the performance of special problem dosimetry. A TL analyzer system for specialized work is shown in Figure 6.

Fig. 6 TL analyzer system.

2.1 Gamma Measurements at the Test Reactor Area (J. P. Cusimano, J. C. Culley)

Dosimetry assistance utilizing TL dosimeters was provided to KAPL. Gamma exposure of the in-pile tube packing material at the ATR sub-pile room was determined. The gamma exposure was primarily from ^{16}N activity in the loop water during normal ATR power operations.

Other gamma measurements were provided for a Teflon destruction study from gamma radiation in the rod access room at the ATR, and to predict gamma exposure to field gland gaskets.

A series of TLD in-core gamma heat measurements was performed at the Engineering Test Reactor Critical Facility. The evaluation data were utilized to correlate measurements with those taken in the ETR.

2.2 Gamma Measurements at the Idaho Chemical Processing Plant (J. P. Cusimano)

Solid state dosimeters were used to obtain a radiation reading from a basket of Peach Bottom fuel placed in the storage vault at the ICPP. Dose rates were in the range of 10^4 to 10^5R/hr.

2.3 Special Measurements at the EBR-II Area (J. P. Cusimano, J. C. Culley)

A measurement of the neutron spectrum and dose rate between the ZPPR reactor halves was attempted. Personnel neutron threshold detectors and TLDs were utilized to perform these measurements. The dose rate and total exposure were too low for an accurate measurement with the threshold detector. The TLDs yielded a more reliable result. Because of this a cooperative informal investigatory program was established with Battelle-Northwest, Richland, Washington to attempt a neutron measurement utilizing their plutonium fluoride and californium calibration sources. This informal study is still in progress.

Argonne National Laboratory requested dosimetry assistance in performing gamma radiation measurements during the destructive irradiation of a gasket material. The radiachromic dye dosimeters utilized received radiation damage to a point where they could not be evaluated accurately. It was calculated that they had received in excess of 10^9R. Because of this, other materials are being investigated that might provide useful information in the range of 10^9 through 10^{11} rad total exposure.

2.4 NRF Environmental Measurements (J. P. Cusimano, M. M. Rasmussen)

A three-month study was performed at the Naval Reactor Facility to determine environmental exposures. A series of TLD badges was placed on the perimeter fence of the NRF complex and on the grid outside the fenced area. There were two monitoring periods of one month and two months to determine the average environmental exposures due to the NRF complex. The badge used was the standard HSL TLD environmental badge. Exposures were reported along with the associated error at the 95% confidence level.

2.5 Radiation Measurements at Test Area North (J. P. Cusimano)

A series of radiation measurements was performed for the low power test section of ANC. TLDs were exposed at various locations in a beryllium oxide slab to determine gamma heating rates. The slab was a mock-up in the spherical cavity gas core reactor experiment at TAN.

3. RESEARCH AND DEVELOPMENT PROJECTS IN DOSIMETRY

3.1 Investigation of Radiachromic Materials (J. P. Cusimano)

Investigation of dosimetric materials such as aminotriphenylmethane dye cyanides (radiachromic materials) that could be utilized in ranges from 10^7 through 10^9 rad was continued. Experiments have determined that the reliability and reproducibility using densitometric methods are not good. Therefore, at the present time a spectrophotometer is being obtained to enable more accurate measurements with the radiachromic materials through the spectrometric change of optical absorption in the visible light region.

3.2 Reactor Gamma Heat Measurements with TL Phosphor (J. P. Cusimano, M. R. Guffey)

Knowledge of gamma heating in the structural materials of the reactor, loops, and experiments is needed to determine cooling requirements and for predicting the magnitude of thermal stresses. Much effort has been expended in determining a suitable thermoluminescent dosimeter material to measure gamma heat in critical facilities. Generally, in-core gamma heat measurements must be made in locations where space for a dosimeter is at a minimum. In order to preserve the environment around the point of measurement, the size of the dosimeter is quite critical. The Dosimetry Branch has chosen the 1 x 1 x 6 mm CaF_2:Mn dosimeter for in-core use. It is dose-rate independent and has a dose range through 10^6 rad.

Relative error is important in determining the uncertainty in the distribution of gamma heat values utilizing this measuring technique. One of the largest sources of error is the sensitivity of the dosimeters. An estimate of the magnitude of the relative error is made by irradiating a large number of dosimeters to the same exposure and then determining the distribution of the readout of these dosimeters. It was determined that at the 95% confidence level the standard deviation was as high as ±20%. To reduce the relative error of measurement, the dosimeters are preselected within ±5% of the mean value of the distribution. This preselection eliminates dosimeters which are irregular in weight or physical properties which would affect their response to gamma, relative to the dosimeters which

Preliminary programs to control and acquire data from the new automatic thermoluminescent dosimeter analyzer were completed. These programs will allow the operator to obtain data on a channel-by-channel basis or by integration of four selectable regions. The listing displays the value of the integrating picoammeter at the time the sample was taken, in one column, and the net increase in that value since the last sample was taken, in another column. The sample rate is dependent upon the stepping rate of the dosimeter under the heating bar of the analyzer. The programs will run in the PDP-8/S computer which is the control unit of the system.

A program is being developed as an aid in the sorting and statistical analysis of TLD crystals used in the Regulatory and special problem dosimetry programs. Before use, TL materials must be annealed and sorted according to their radiation sensitivity. This difference in sensitivity necessitates regrouping TL crystals according to like sensitivity. The computer program provides a means of selection according to sensitivity and furnishes statistics as an aid in the selection. This program is as yet incomplete as the selection and statistics need to be more thorough.

The ROCINANTE program, described in the 1970 Annual Report, has been rewritten for use on large computers. As a consequence, analysis time has been reduced from several weeks to several days to spectrum-strip a TLD data set. Photopeak sensitivity has been increased mathematically to the point where it appears to bear relationship to the fields of crystallography and X-ray spectrography.

The Regulatory Program computer program has been finalized and tested. Last minute modifications were incorporated to allow printout of a formal report page suitable for presentation to HQ Washington. Additional changes were made in the statistical error computation and data processing sections of the program that will allow the operator more flexibility in its use and efficiency in its operation.

3.4 Automatic Thermoluminescence Analyzer System (ATLAS) (J. C. Culley)

As stated in the 1970 Annual Report, the Branch is involved in the design and fabrication of an automatic thermoluminescence dosimetry system to replace the photographic dosimetry system at the NRTS.

It was hoped this system could be initiated in June 1971. However, continuing difficulties in devising a method for identifying the dosimeters have caused considerable slippage in the schedule. The original optical character recognition system and the binary code marking along the edge of the dosimeter have proved to be unsatisfactory.

The nonuniformity in the bonding of the various marking fluids with the Teflon dosimeter was not compatible with the electronic sensitivities required. Present efforts are being directed toward a 10 x 9 matrix system which will not require such extremely close tolerances in spacing and sensitivity. The system should be operable in early 1972.

IV. INSTRUMENTATION BRANCH

(M. Wilhelmsen)

1. ROUTINE INSTRUMENTATION ACTIVITIES

1.1 Field Instruments Maintenance

During 1971, 1988 individual repairs and calibrations were performed on portable instruments in the radiation instrument pool. Although this number is 360 less than was reported for 1970, the contractor usage of the portable instruments during 1971 was approximately the same as in 1970. This reduction was made possible through a general upgrading of the portable instrument pool quality. New electronic circuit techniques have produced extended battery life and increased instrument reliability.

Eighty-four new portable instruments comprised of five different types have been added to this pool. These additions provide increased range and greater sensitivity and detection capabilities at lower energy levels.

1.2 Maintenance of Laboratory Instrumentation

The maintenance of the instrumentation required for the various functions of the Health Services Laboratory is a major responsibility of the Laboratory Systems Section. Instruments needing maintenance range from simple single circuit devices to the more complex and sophisticated systems and peripherals deemed necessary in the Laboratory's exacting assignments. The workload increases each year as additional equipment is acquired to meet the ever-increasing demands for greater precision and excellence. Methods used to keep up with the maintenance requirements include specialization growth of personnel in the branch and utilization of field service engineers who represent the vendors of specialized equipment.

A part of the instrumentation program is the modification and adaptation of instruments so that they can perform related functions other than those for which they were designed. A small but complete staff machine shop is maintained and operated in order to support the instrumentation maintenance and modification programs and for building special equipment needed for experimentation and unusual Laboratory activities.

2. SPECIAL INSTRUMENTATION SUPPORT ACTIVITIES

2.1 Routine Telemetry System (D. G. Hill, L. M. Talbot, D. Johnson)

A new solid state telemetry system network comprised of a base station (Figure 7) and 13 remote field stations has been installed in replacement of the 16-year-old telemetry system. This new system provides radiation information and air sample control required by the Environmental Branch and weather information for NOAA studies. All data are recorded on magnetic tape for computer processing. Nine new remote field stations are on order to expand the system network.

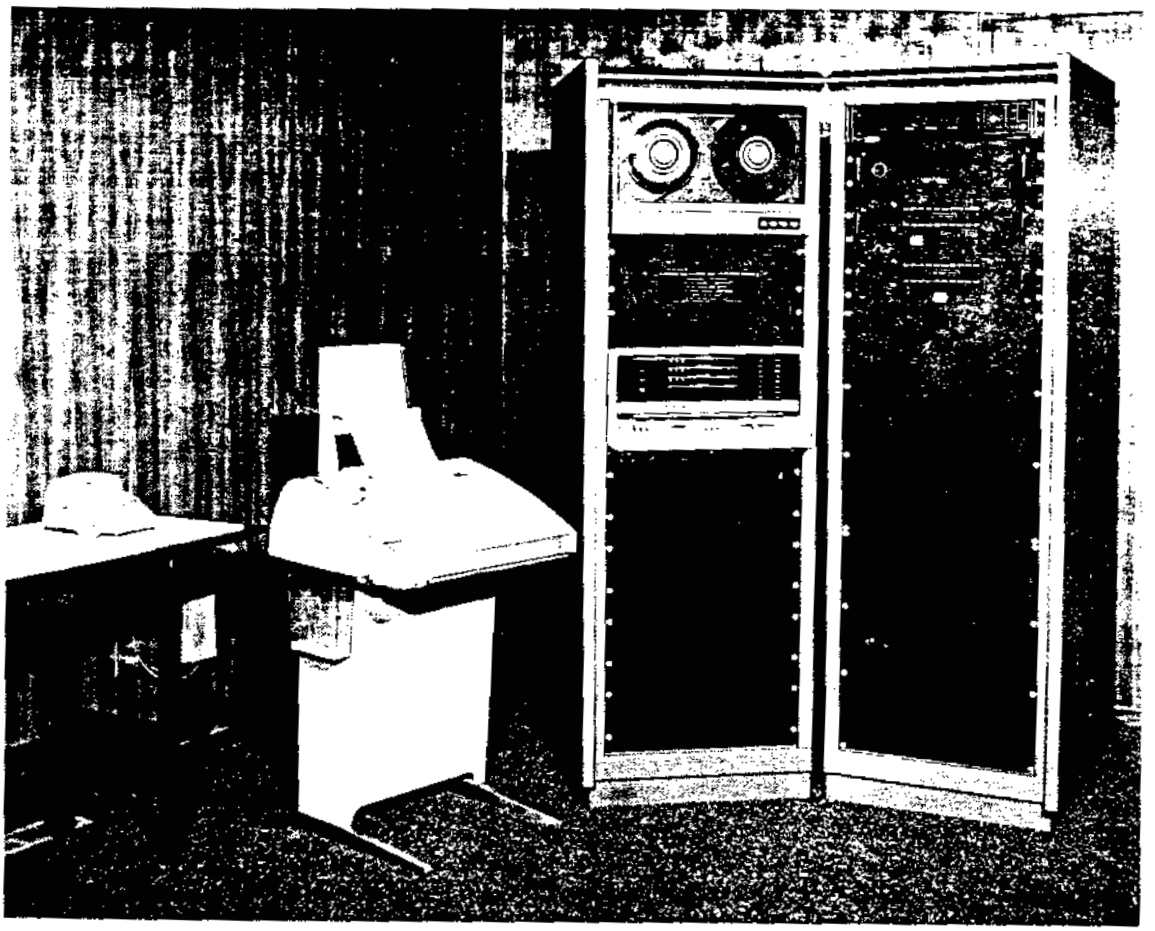

Fig. 7 Telemetry system base station.

2.2 Telemetry Interface Circuitry (D. G. Hill, L. M. Talbot, D. Johnson)

Thirteen interface package systems were designed and fabricated to accommodate the variety of input signals and controls required at each remote field station of the telemetry system. This package also includes power modifications for remote station operation in event of commercial power failures.

2.3 Special Circuitry Development (D. Johnson)

The following special electronic circuits were designed and constructed in support of the various programs indicated below.

Analog Averaging for Wind Sensors

This circuit provides the average wind speed and direction in vector form and voltage range acceptable to the telemetry remote field station.

GM Tube Count Rate Circuit

This circuit provides a 0 to 10mR/hr output from a GM tube in a voltage range acceptable to the telemetry remote field station.

3. INSTRUMENTATION RESEARCH AND DEVELOPMENT PROJECTS

3.1 System for the Detection *In Vivo* of Low-Energy X-Rays (D. Parker, K. H. McGary)

A system has been developed for detecting *in vivo* low-energy X-rays such as those which emanate from decaying ^{239}Pu. The detector is a custom-built proportional counter which is especially sensitive to X-rays in the 17 keV region. Pulses from the detector are first amplified by an adjacent sensitive FET preamplifier and then by a linear amplifier. The amplified pulses are converted to digital equivalents by an ADC and then sorted and stored in the memory of a PDP-8/I computer as a pulse-height spectrum. An oscilloscope interfaced to the system provides a constant display of the spectrum buildup and aids the operator in choosing upper and lower channel-limits of interest. Programming via the computer provides a choice of nonlinear amplification factors, a choice of the numbers of adjacent channels to be averaged for curve smoothing, a method for stripping background away from the gross spectrum, and the capability of driving a digital plotter for plotting the resultant spectrum. Figure 8 shows a spectrum of ^{239}Pu before and after enhancement by the system.

3.2 Automatic Thermoluminescence Analyzer System (D. Parker, K. H. McGary)

An improved automatic thermoluminescence analyzer system, designated Atlas III (Figure 9), is being designed and constructed. The reader will accept Teflon-TL dosimeters which are equivalent in size to the regular photographic films which have been in use at the NRTS. Each dosimeter is automatically picked up from a hopper by a transport mechanism, moved to a preheat station and raised to a temperature of 135°C, moved to a readout station where each of four differently filtered areas is heated to the TL discharge temperature and read out in sequence, moved past a badge identification station, and finally ejected into a receiving compartment.

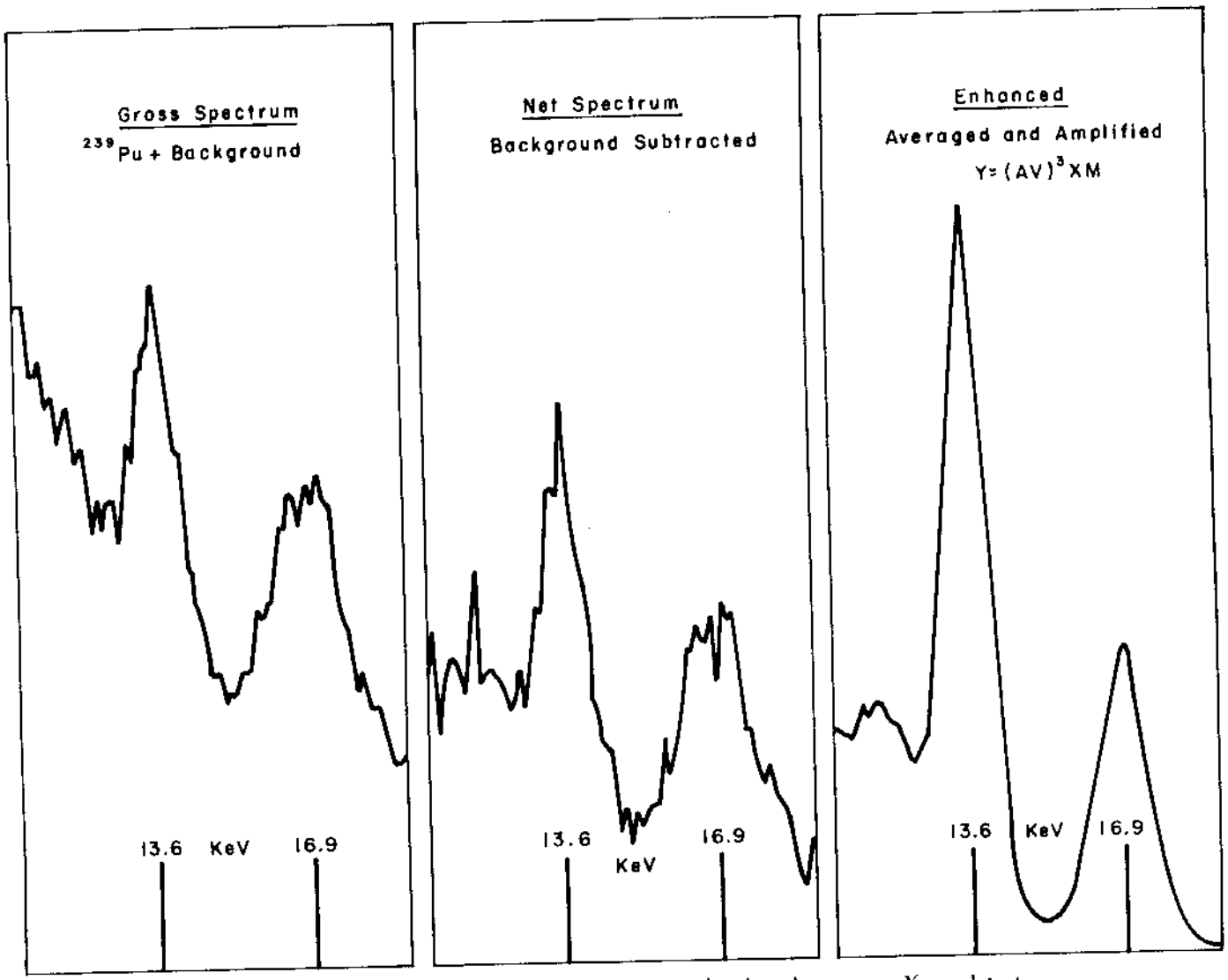

Fig. 8 Spectra demonstrating the capabilities of the *in vivo* low-energy X-ray detector.

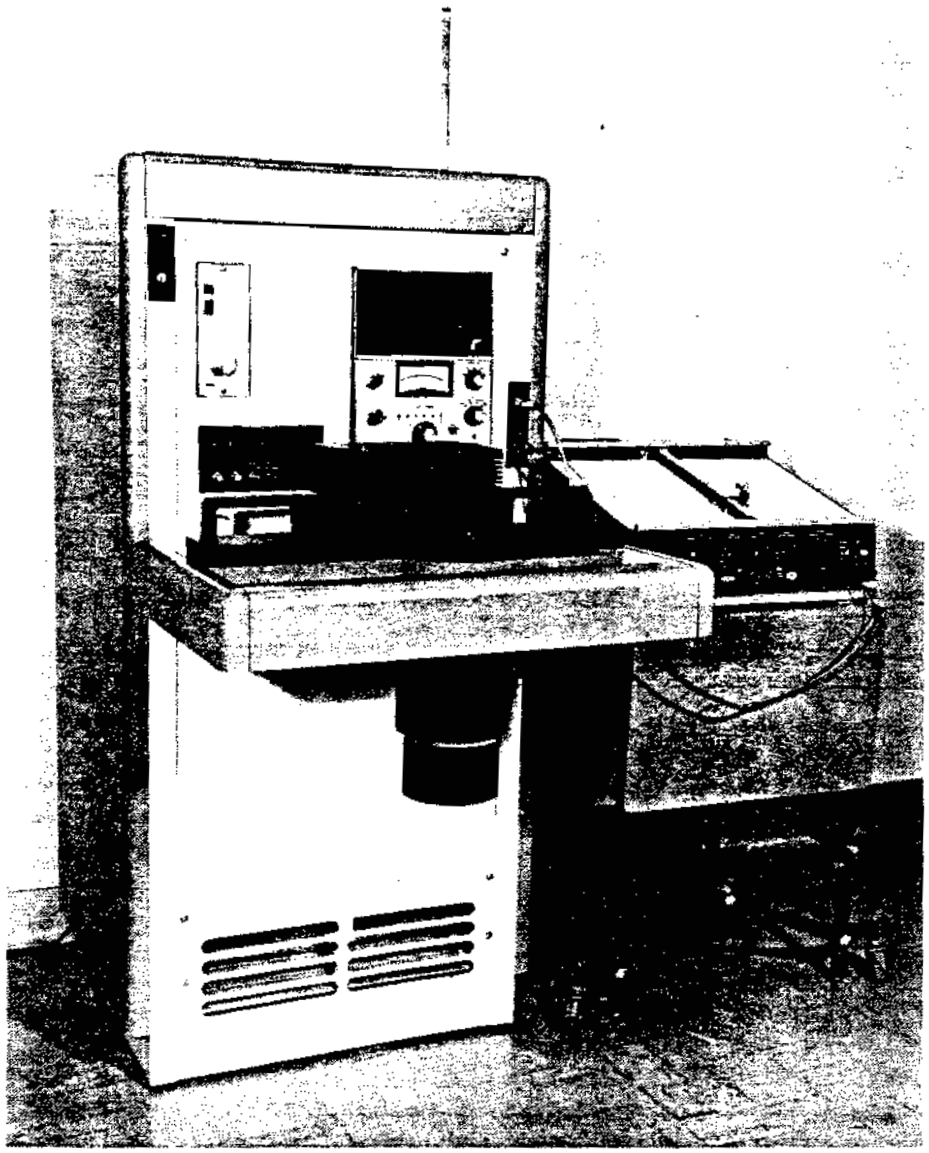

Fig. 9 Automatic thermoluminescence analyzer system (Atlas-III).

V. MEDICAL DEPARTMENT

(J. H. Spickard, M.D.)

Occupational medical services at the NRTS are provided through an organizational system that is unique to the U.S. Atomic Energy Commission medical programs. The AEC Medical Department is responsible for the planning, operation, and direction of this program for NRTS contractors and AEC and other federal personnel. Several of the companies that are served in this program operate under operations offices other than Idaho.

1. MEDICAL PROGRAM

The Medical Department provides a complete occupational health program for most employees at the NRTS. During 1971, site population varied from a low monthly figure of 5324 to a high of 6023. Approximately 25% of the site personnel are military and construction workers who receive a limited amount of medical service.

Facilities include a large dispensary and decontamination building located in the Central Facilities Area (CF), and smaller dispensaries at Test Area North (TAN), Test Reactor Area (TRA), Idaho Chemical Processing Plant (ICPP), Naval Reactor Facility (NRF), Experimental Breeder Reactor II (EBR-II), and Idaho Falls Headquarters Building (HQ). The main dispensary has X-ray and laboratory equipment sufficient for most diagnostic procedures. A medical van containing an X-ray unit and wholebody counter is used for supplemental testing in Idaho Falls and remote plant areas.

Medical personnel include three physicians, seven AEC nurses, five contractor nurses, two medical technologists, an X-ray technician, a secretary, and a receptionist. The main dispensary is staffed seven days a week, 24 hours per day, by AEC shift nurses. Contractor nurses staff plant dispensaries and an AEC nurse operates the HQ dispensary during the normal work week. Physician coverage is provided at the HQ dispensary two or three mornings a week.

2. MEDICAL STATISTICS -- 1971

2.1 Trends

Although the site population has been relatively stable, there have been changes in emphasis on specific programs. These are reflected in the medical statistics. During 1970, because of a decrease in construction activity, the full-time construction nurse at LOFT was terminated. The fact that there have been fewer construction workers on site in 1971 and that many occupational injuries among these workers are now treated at area dispensaries rather than first aid stations has resulted in a decrease in first aid station activity. During 1971, continuous nurse staffing was not possible at NRF and a significant reduction in the number of treatment visits resulted (the majority of these were of a nonoccupational nature). By the end of 1971, 815 AEC and contractor personnel were stationed in Idaho Falls (at Headquarters Building and Annex, Computer Center, Rogers Building). If military and construction personnel are excluded, this represents approximately 20% of AEC and

contractor personnel. This may result in an eventual need for increased staffing and coverage at the HQ dispensary.

During 1971 the prime ID contractor was changed from Idaho Nuclear Corporation to Aerojet Nuclear Company and Allied Chemical Corporation. This change had no substantial effect upon medical activities or site population.

2.2 AEC Dispensaries -- Treatment Visits

Treatment visits to AEC dispensaries increased from 8074 in 1970 to 8244 in 1971; however, there was a decrease in visits to the CF dispensary. This year, more than 35% of treatment visits were made to the HQ dispensary as compared to 25% in 1970. Less than 2% of these treatment visits were occupational whereas 19% of those to the CF dispensary were occupational in nature.

In addition to 8224 treatment visits at AEC dispensaries in 1971, 2667 visits were made for other reasons (physical examinations, laboratory work, X-rays). Distribution of visits to AEC dispensaries during 1971 is shown below:

Idaho Nuclear Corporation	30%
Aerojet Nuclear Company	27%
Atomic Energy Commission	23%
Westinghouse Electric Company	8%
Argonne National Laboratory	6%
Construction Contractors	2%
Allied Chemical Corporation	1%
Other Federal Employees	1%
Other	2%

Figure 10 depicts the trends for Central Facilities and HQ dispensary visits.

2.3 Patient Visits to All NRTS Dispensaries

There were 27,684 visits to all NRTS dispensaries and first aid stations in 1971. This decrease of 8000 from 1970 can be accounted for primarily by a reduction in the number of visits to the NRF dispensary and in construction activity. Decreased NRF dispensary visits resulted from a loss of nursing services at that dispensary for a period of time. Fifteen percent of treatment visits sitewide were for occupational injuries, the same proportion as last year. Table IV shows the distribution of treatment visits at all NRTS dispensaries in 1971. Additional visits for X-ray, laboratory, and physical examinations are not included in these figures.

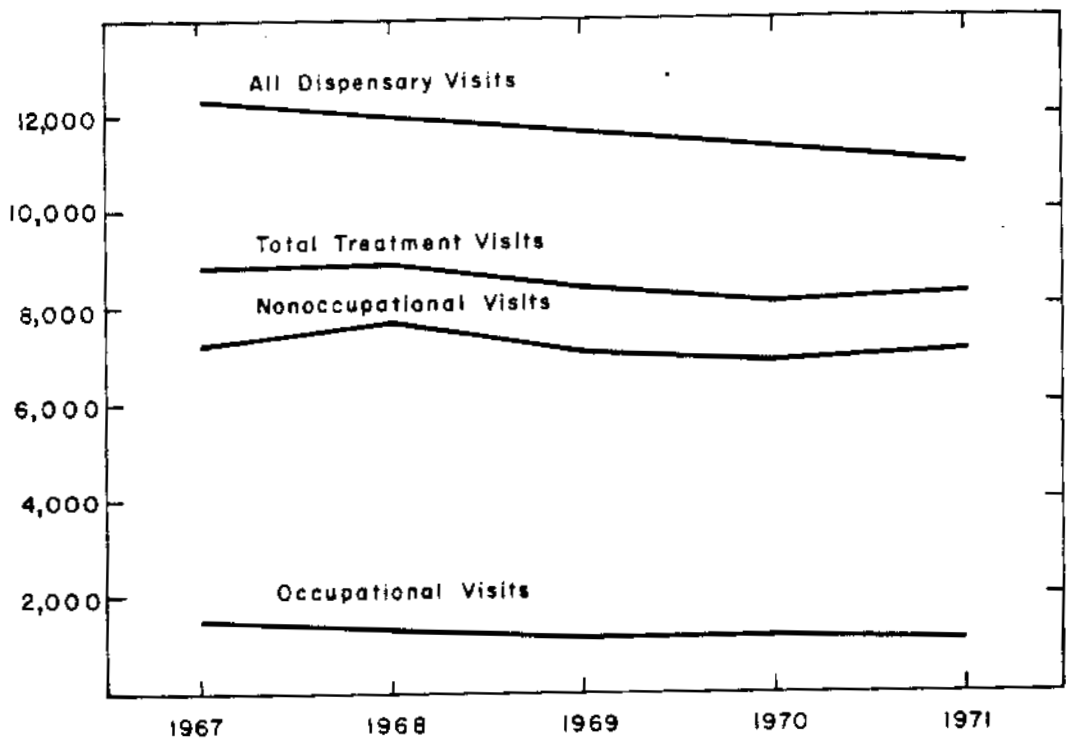

Fig. 10 Central Facilities and Headquarters dispensary visits.

TABLE IV

TREATMENT VISITS -- ALL NRTS DISPENSARIES 1971

	Occupational	%	Nonoccupational	%	Total
CFA	1011	19	4218	81	5229
HQ	51	2	2944	98	2995
NRF	1293	17	6425	83	7718
EBR-II	440	13	2920	87	3360
TRA	148	10	1339	90	1487
ICPP	141	12	1001	88	1142
TAN	141	16	731	84	872
First Aid	215	47	247	53	462
	3440	15	19,825	85	23,265

2.4 Physical Examinations

Physical examinations are performed at time of hire and periodically throughout employment. The general schedule for examination is as follows: at time of hire, at ages 25, 30, 34, 37, and 40, every two years until age 62 and then annually. Special examinations are performed at more frequent intervals as indicated for employees in special work categories. Many of these are not reflected in the total physical examination statistics since often these are modified or partial exams. A preplacement medical health questionnaire has been used to determine acceptability for employment prior to hiring. Experience with this form has been gratifying. Decisions made on questionnaire evaluation correlate well with those made after physical examination. In 1971, 408 job applicants were evaluated by this method.

Complete histories (health, family, and work), physicals, and laboratory procedures are performed at the time of the periodic physical examination. Testing includes: visual and auditory acuity, spirometry (for breathing function), tonometry (test for glaucoma), hemoccult (to detect internal bleeding), PAP smear (for detection of cancer of the uterine cervix), electrocardiogram, chest X-ray, complete blood count, urinalysis, and SMA 12/60 blood chemistries.

All employees complete and sign a brief health and occupational history questionnaire at time of termination. Over 1000 people completed this procedure in 1971 but these figures are not reflected in the physical examination category.

Slightly less than 2000 physical examinations were performed in 1971, 15% of these in the HQ dispensary. Figure 11 illustrates the trends in physical examinations in recent years.

2.5 Laboratory, X-Ray, and Medical Van

A total of 30,882 laboratory procedures was performed in 1971. Of these, 13,296 were tests included in 1108 blood chemistry examinations performed by a local analytical laboratory. Five hundred and fifty abnormal blood chemistries were identified in these SMA 12/60 profiles. Laboratory examinations conducted at the CF dispensary include a wide variety of procedures: complete blood counts and routine urinalysis, stool testing for occult blood, several chemistries (uric acid, cholesterol, blood sugar and glucose tolerance tests, transaminases), special tests (blood test for infectious mononucleosis, urine test for pregnancy, water culture, cafeteria cultures, water analysis for hexavalent chromium), pulmonary function testing, and electrocardiograms.

Twenty-two percent of the 4426 X-ray examinations were made in the medical van. The van was stationed in town one day a month and X-rays were taken in conjunction with physical examinations of AEC and contractor personnel located in Idaho Falls. This facilitates scheduling, minimizes time loss from work by employees, and relieves the Idaho Falls Navy dispensary of X-ray responsibilities for other than naval personnel. The medical van was also used in plant areas for routine and special wholebody counting. During 1971, 936 employees were examined for internally deposited gamma emitters. Activity was identified in 20 people. Both ^{60}Co and ^{137}Cs were found, with ^{60}Co being more prevalent. In all cases, quantity of material identified was less than 0.1 microcurie.

Figure 12 shows the number of wholebody counts and X-ray examinations performed over the last five years.

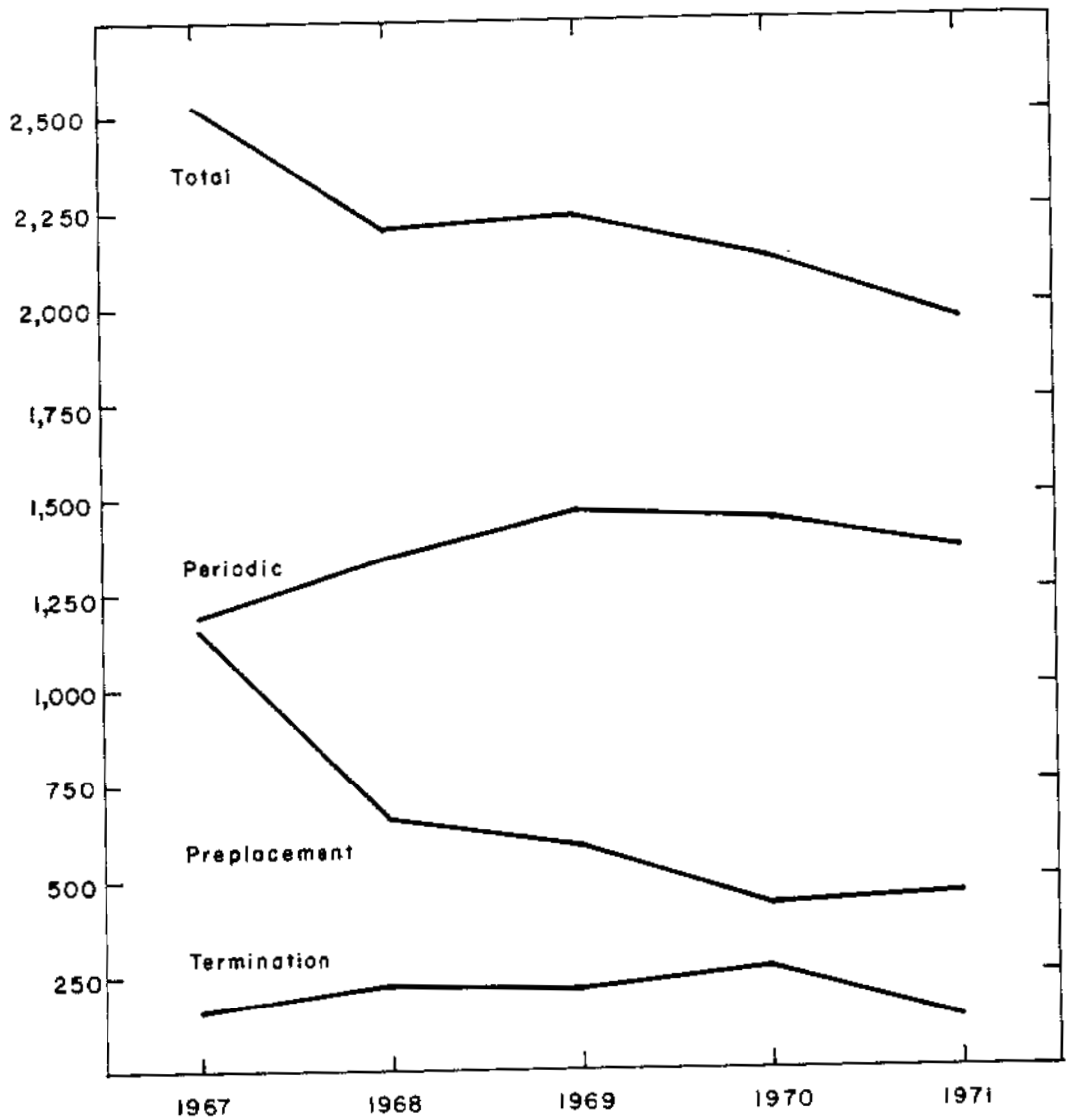

Fig. 11 Physical examinations performed at NRTS.

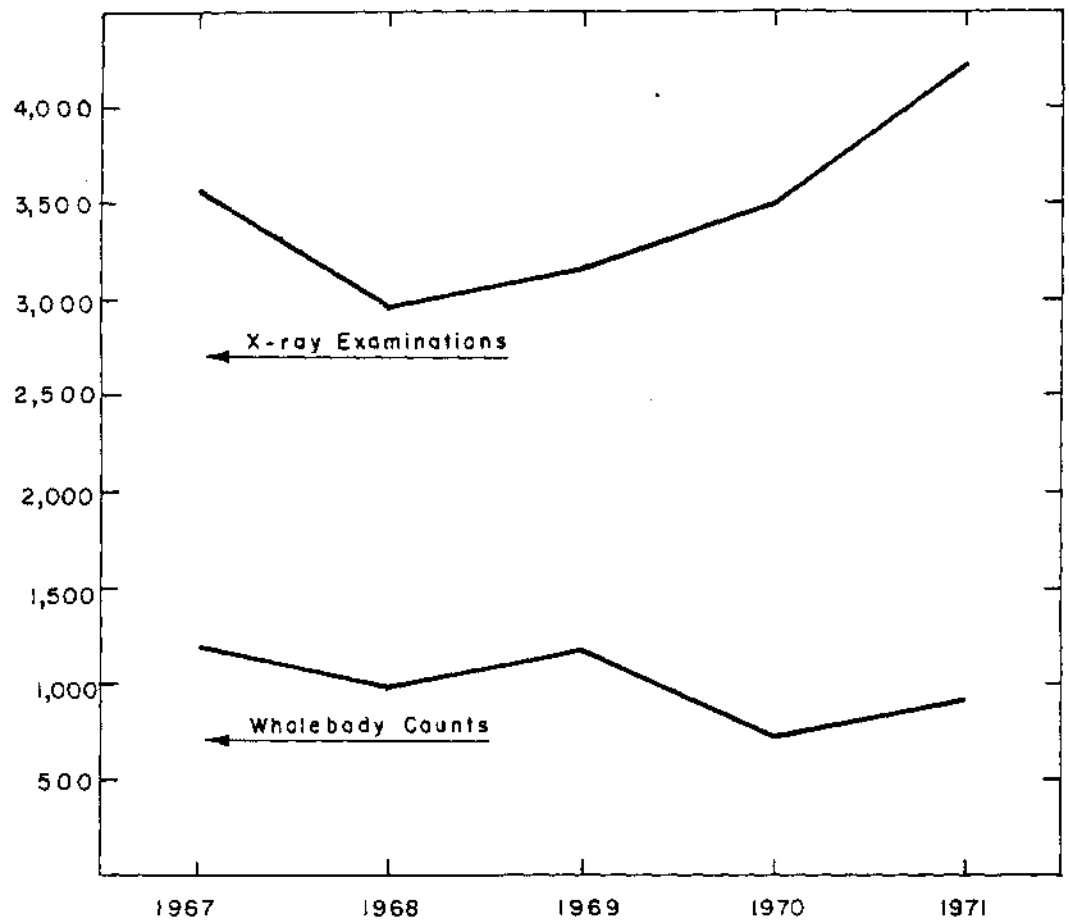

Fig. 12 X-ray examinations and wholebody counts.

3. SPECIAL ACTIVITIES

3.1 Computer Programs

The availability of new computer equipment has facilitated the collection, retrieval, and statistical evaluation of many medical items. A PDP-8/S is now used to describe numerically pulmonary function data collected on the Jones Pulmonor. These data as well as some questionnaire information are being recorded by means of the Mark IV system for data manipulation. Some initial comparisons of pulmonary function data with historical information have been attempted but no conclusive positive correlations have yet been established.

The Mark IV system has also been valuable in two other medical programs. In the first, information is recorded at time of periodic physical examinations on the presence of chronic diseases or the use of certain medications. This information is coded and compiled so that chronic disease information can be determined on NRTS employees. This information is collected in conjunction with the routine use of the computer for scheduling of physical examinations.

Second, the ID-13, Report of Occupational Injury or Illness, was recently revised to provide enough information to satisfy the Occupational Safety and Health Act (OSHA) of 1970. A supplemental form, ID-13A, has been prepared for coding by Medical Department nurses so that information from the ID-13 can be directly keypunched and recorded. The new ID-13 will satisfy the requirements of OSHA as a record of injury, and the data recorded will provide readily retrievable information for the yearend reporting requirements. There is a distinct advantage to the use of the Mark IV system compared to the previous one since a wide variety of data can now be retrieved. This will permit a more complete approach to the investigation of occupational illnesses and injuries.

3.2 Occupational Safety and Health Act of 1970

The impact of the Occupational Safety and Health Act of 1970 has been significant at the NRTS as with other organizations throughout the country. Although the general medical, safety, and industrial hygiene program at the NRTS satisfies requirements of the new Act, specific recordkeeping requirements have resulted in modification of mechanisms for accident reporting and collection of environmental data. Perhaps the greatest pressure from the new legislation is placed on individuals with industrial hygiene responsibility. An extremely extensive sampling program will be necessary on a continuing basis to show that the environment is not hazardous. At the NRTS, a more vigorous asbestos control program will be undertaken. This will include an alteration in the sample collection technique as well as in sample evaluation. Although "asbestos counting" has been performed by the Environmental Branch of the HSL until this time, future examinations will be done elsewhere. The Hanford Environmental Health Foundation, Richland, Washington, has agreed to analyze asbestos samples at a rate of $5 each. This is approximately one-half the cost of having these done at the NRTS by a contractor.

3.3 Industrial Psychology

In October 1971, Dr. Sanford Bunin, Industrial Psychologist from Hanford, visited the NRTS to discuss a long-term industrial psychology program. He presented two three-hour sessions on various aspects of industrial psychology to AEC and contractor personnel in Idaho Falls and at the NRTS. By the end of 1971, a tentative agreement had been reached with the Eastern Idaho Mental Health Center to provide consulting services to the Medical Director for the purpose of establishing a program in the field of industrial mental health. This program is to include: training for nurses in counseling techniques, training for Security personnel in determining how to evaluate and handle alcohol and drug abuse problems, supervisory and employee group training on recognition of mental illness, alcoholism, and drug problem management. Many special programs may be possible under this form of consulting arrangement.

3.4 Emergency Planning During 1971

Hospital and plant programs for handling of radiologically contaminated casualties were reviewed at the LDS Hospital in Idaho Falls and at EBR-II. Dr. Spickard spent some time with the emergency room staff at the LDS Hospital to describe the important phases of a program involving the management of these casualties. Proposed decontamination areas were identified at the EBR-II site, and recommendations were made for a general emergency response program.

The Security Division assisted in the preparation of video tapes of lectures prepared and presented by local physicians to ambulance personnel. These tapes are available for training use for personnel of the AEC Fire Department and other emergency groups.

3.5 Audiometry

During 1971 the proposed training course for audiometric technicians was presented at the NRTS by Michael A. Nerbonne, Ph.D., Department of Speech and Audiology, Idaho State University. NRTS nurses received certification as audiometric technicians as a result of this training. An audiometric acoustical booth was purchased and installed in the HQ dispensary so that audiometry performed at that facility would be consistent with testing in other areas. All audiometers at the NRTS have been recalibrated to the ISO-1964 Standard within the past year.

3.6 Tape Library

Because of the wide variety of educational programs that members of the Medical Department attend, a library of cassette tapes is being developed. A number of educational tapes are available through the Intermountain Regional Medical Program and from pharmaceutical manufacturers. The remainder will consist of tapes recorded by medical personnel from the NRTS during their attendance at meetings.

4. PUBLICATIONS AND PRESENTATIONS

P. B. Anderson and J. H. Spickard, MD, "An Evaluation of Orthopedic Stretchers," *Emergency Product News,* May/June (1971).

L. E. Howard, Jr., J. H. Spickard, M. Wilhelmsen, "A Human Radioactivity Counter and Medical Van", *Health Physics, 21,* 417 (1971).

G. L. Voelz, MD, and J. H. Spickard, MD, "Pre-Employment Medical Evaluation by Questionnaire", paper presented at the Annual Meeting of the American Academy of Occupational Medicine (February 1971). Accepted for publication in the *Journal of Occupational Medicine.*

J. H. Spickard, MD, "An Occupational Lead Exposure Experience", paper presented at Occupational Health Conference sponsored by the Pacific Northwest Chapter of the American Industrial Hygiene Association, October 1971, Idaho Falls.

VI. ENVIRONMENTAL BRANCH

(A. H. Dahl)

I. ROUTINE ACTIVITIES

1.1 Environmental Monitoring (R. L. Bangart, D. L. Newcomb, W. L. Polzer)

The concentrations of radioactive materials in air are monitored continuously by drawing air through particulate and charcoal filters at eight onsite and eight offsite locations. These filters are changed weekly and counted for long-lived alpha and beta radioactivity. Direct radiation in the environment is also monitored using thermoluminescent dosimeters (TLD) which are exposed for six-month intervals.

The total suspended particulate material in the atmosphere on and off site is measured routinely. Monthly determinations of the dust fall rate onsite are made. Development of monitoring stations for measuring SO_2 and NO_x concentrations in onsite air was begun and substantially completed.

Weekly composite samples of milk from the Idaho Falls milk shed are collected and analyzed for ^{131}I and ^{137}Cs. Analyses for ^{90}Sr are made semiannually. Samples of wheat are collected throughout southeastern Idaho at harvest time and are analyzed for ^{90}Sr and for gamma-emitting radionuclides.

Groundwater is monitored routinely to determine the fate of radioactivity released via seepage ponds and disposal wells. All NRTS production wells are sampled weekly. Twelve offsite stations located down the groundwater gradient are sampled semiannually. Monitoring wells in the immediate vicinity of disposal facilities are sampled on a variable schedule. The results are also used in research programs dealing with the fate of radionuclides in the groundwater.

A continuous surveillance program is maintained at the NRTS burial ground to monitor radioactivity in the lithosphere. This program includes analyzing sediments from the ground surface to basalt. The results obtained from the U. S. Geological Survey study of drilling four regional water wells outside the burial ground and core drilling inside the burial ground will be used for planning future surveillance work. The regional wells will be sampled quarterly.

Quarterly and semiannual environmental monitoring summaries are prepared for ID and contractor use. The summaries include results from air, water, and radiation monitoring at the NRTS.

1.2 Independent Measurements Program (R. L. Bangart, D. L. Newcomb, J. E. Tedford)

The Branch assisted in the Division of Compliance program of environmental monitoring in the vicinity of nuclear facilities. This involved coordination of sampling at the facilities and the analyses of the samples performed by the Health Services Laboratory, interpretation of data, and preparation of reports. Routine environmental monitoring programs were conducted from January through December around a nuclear fuels

reprocessing plant, a boiling water power reactor, a pressurized water power reactor, and a radiochemical supply laboratory. Monitoring continued throughout the year around a scrap recovery and fuel fabrication plant. In addition, direct radiation levels in the vicinity of two other operating nuclear power plants were measured.

1.3 Emergency Response and Preparedness (B. D. Johnson, P. G. Voilleque')

The Branch is responsible for evaluating hazards to on- and offsite personnel resulting from planned and unplanned releases of radioactivity to the environment and for recommending actions to minimize personnel exposure in the event of an emergency. Portable emergency kits are maintained for use in response to onsite emergencies and for ID Radiological Assistance Team responses in Idaho, Colorado, Montana, Utah, and Wyoming. A group of five trailers and the associated health physics equipment and supplies are maintained in readiness for establishing an operations command post and a health physics

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Long Distance Diffusion Tests (P. G. Voilleque' in cooperation with NOAA)

Two field tests to obtain data on transport and diffusion of airborne material at distances as great as 80 kilometers from a point source were conducted. Methyl iodide, labeled with ^{131}I, was released for a period of approximately one hour; air concentrations were determined using high volume air samplers located along arcs approximately 6, 19, 48, and 80 kilometers downwind. Lateral spread of the tracer, measured by σ_y, was found to be consistent with results of earlier short range tests using uranine dye. The measured relative axial concentrations were found to be higher than those expected on the basis of the earlier uranine dye releases; however, at least part of the discrepancy was related to the limited depth of the mixed layer (~1400 m) at the time of release.

2.2 Controlled Environmental Release Test (CERT) Program

The objectives of the CERT program are to (a) define variables which affect the transfer of radionuclides from the point of release to the atmosphere to a human receptor, (b) perform controlled experiments to measure the variables influencing the observed transfer phenomena, and (c) develop and test predictive models of the processes involved. The principal focus of this program presently is to evaluate transfer of airborne contaminants to natural and man-made surfaces and the retention of the deposited material by the surfaces.

A significant amount of effort was devoted to modifications of the environmental chamber and associated instrumentation to permit proper operations.

Other areas receiving attention are listed below:

(1) Bovine Metabolism of Radioiodine (P. G. Voilleque', D. R. Adams, C. A. Pelletier)

Detailed analysis of data from two previous single-dose radioiodine metabolism experiments, performed in cooperation with B. R. Moss of Montana State University, was completed. Six cows were fed either Sudangrass or bromegrass green chop *ad libitum* as the only forage following dosing with ^{125}I or ^{131}I at the beginning of the experimental period. Feeding Sudangrass decreased the average percentage secretion of the radioiodine dose per kilogram of milk from 0.090 to 0.048; the probability, P, that the difference is due to chance is less than 0.01. Feeding Sudangrass also reduced the average milk/plasma ratio from 2.1 to 1.9 ($P < 0.05$). Fecal and urinary excretion percentages were higher on Sudangrass feed but were not significantly different ($P > 0.10$) due to larger variability among the experimental animals.

(2) Transfer of Hypoiodous Acid from Air to Grass (C. A. Pelletier, D. R. Adams, P. G. Voilleque')

A laboratory experiment was conducted to evaluate the transfer of hypoiodous acid (HOI) from air to pasture grass. The generation of HOI-131 was performed by J. H. Keller, Idaho Chemical Programs - Operations Office, Allied Chemical Corporation. Bromegrass in 25- by 25-cm pots was exposed in a plexiglass exposure chamber; the mean linear velocity of the HOI-contaminated air above the grass was 1 m/sec. Because experimental conditions preclude comparison with normalized transfer velocities obtained in field experiments, an analogous quantity, the transfer parameter P_t (g^{-1}) [see *Health Physics 21*, 771 (1971)] is used for comparison with molecular iodine gas. For bromegrass with closed stomata a value of $P_t = 2.4 \times 10^{-5}$ g^{-1} was obtained for HOI. For five experiments in which I_2 labeled with ^{131}I was released into the chamber containing grass with closed stomata, a value of $P_t = 2.4 \pm 0.9 \times 10^{-4}$ g^{-1} (sample standard deviation indicated) was obtained. If environmental conditions were favorable for stability of HOI, transfer of radioiodine released as HOI through the milk-food chain would be reduced in comparison with that for radioiodine released as I_2.

2.3 Movement of Radionuclides in Soil (J. B. Echo, W. L. Polzer)

Core samples from the bottom of the Test Reactor Area (TRA) 1964 pond were taken and prepared for analyses in order to determine the distribution of radionuclides with depth and their distribution between the alluvium and the soil water. The results of this study will be compared with similar studies performed in previous years. The distribution and amount of nuclides in the alluvium near the Fuel Cutting Facilities at ICPP were also estimated on the basis of water and sediment samples collected from auger holes.

A cooperative laboratory research study is in progress on plutonium behavior in soil/water environments. The coinvestigators are Drs. W. L. Polzer of the Laboratory and F. J. Miner of the Rocky Flats Division, Dow Chemical Company. The purpose of the study is to evaluate those parameters which affect the movement of plutonium in soil/water environments, ie, diffusion coefficients, distribution coefficients, breakthrough curves for plutonium in soils, and solubility of plutonium under environmental conditions.

2.4 TRA Pond Studies (J. B. Echo, W. L. Polzer)

In 1970 the infiltration of liquid waste decreased to the extent that the 1964 pond was not capable of releasing the discharged liquid to the soil and nearly overflowed. The pond was drained and kept dry for a period of several months. Observations suggested that algae and calcium carbonate crust buildup could have affected the infiltration rate. A laboratory study was completed in 1971 which showed that both algae and calcium carbonate significantly affected the infiltration of pond water into columns of alluvium. Drying of the algae column restored the infiltration to its original rate whereas drying of the carbonate column did not.

2.5 Tritium Studies (J. H. Osloond, J. B. Echo, W. L. Polzer, B. D. Johnson)

Evaluation and further development of a practical sampling method was made to measure tritium air concentrations. In the method, atmospheric moisture is collected on

silica gel and a 5-gram aliquot is counted in a liquid scintillation detector. The counting yield for analyzing tritiated water on silica gel is within 3% of that for liquid samples. Silica gel moisture collection efficiency is 95% for an air flow-rate around 6 liters per hour with a temperature range of 0 to 27°C and relative humidity between 10 and 95%. Field evaluation involved sampling of atmospheric air around the Nuclear Fuel Services plant in New York as well as at the NRTS. Field evaluation of the sampler is still in progress.

A study on the question of selective absorption of tritiated water by precipitated aluminum hydroxide is being continued. Preliminary data indicate that a small enrichment of tritium to hydrogen occurs in the structural water of bayerite, an aluminum hydroxide polymorph. Also the amount of enrichment is dependent on the temperature at which the structural water is collected.

2.6 Snake River Plain Seismicity

Three Strong Motion Accelerometers were installed at three critical locations at the NRTS late in the year. A more complete system including offsite triggers is being designed and procured through NOAA-Boulder. One vertical motion continuous seismic recorder was installed near the HSL building and daily records have been obtained and analyzed. The earth vibrations caused by the NRTS buses have caused some interference. In early 1972 two more vertical motion continuous seismic sensors will be installed -- one on Howe Peak and one on Taylor Mountain which are both off the Snake River Plain, on the north and south sides, respectively. Any decoupling action at the borders of the Snake River Plain may be indicated by this new system. A deep resistivity survey was made by the USGS across the Snake River Plain from Arco to Blackfoot. The preliminary results indicate a deep subsurface silicic volcanic-filled trough at the south edge of the plain and a discontinuity at the north edge of the plain.

3. PUBLICATIONS AND PRESENTATIONS

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P. G. Voilleque', "Dependence of Maximum Permissible Air Concentrations of Strontium-90 and Plutonium-239 on Aerosol Properties", paper presented at the Health Physics Society's 16th Annual Meeting, New York (July 1971).

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VII. U. S. GEOLOGICAL SURVEY

(J. T. Barraclough)

1. HYDROLOGIC INVESTIGATIONS AT NRTS

The U. S. Geological Survey investigates and describes the water resources and geology at the NRTS and adjacent areas. The studies, supported by the Atomic Energy Commission, determine the influence of disposal of liquid low-level radioactive and chemical wastes to the subsurface at the NRTS. A continuing program of investigation serves to determine natural changes in the geohydrology and changes brought about by activities at the station. The USGS also serves as geohydrologic consultants to the AEC.

During 1971, a total of 900 measurements of the water level in about 210 different wells was made to denote changes in water storage in the Snake River Plain aquifer and in perched groundwater bodies. About 200 groundwater samples were collected to evaluate water quality changes. An average of two chemical and/or radiochemical analyses was performed on each of these samples. Twelve wells and ponds were equipped with continuous water-level recorders. Three continuous discharge (flowrate) stations were operated on the Big Lost River and five direct stream discharge measurements were made. About 25,000 feet of logs were run in wells with geophysical and radiation probes to determine water and rock properties.

The flow of the Big Lost River at the NRTS Diversion during 1971 was about 180,000 acre-feet. This is the third highest flow on record. The two higher flows occurred in 1965 and 1969 and the fourth highest flow was in 1967. The cumulative effects of this unusual recharge on the Snake River Plain aquifer and the dilution of the nearby radioactivity in the aquifer are being studied. Recharge from these record flows caused the water in wells in the western part of the NRTS to rise to record high levels again in 1971.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Investigations of the Influence of Underground Waste Disposal

The geohydrologic study of the influence of long-term waste disposal to ponds and wells continued. Additional values on volumes, compositions, and locations of waste discharges were compiled. Materials balance analyses for waste sodium, chloride, tritium, strontium-90, cesium-137, and temperature were computed. Almost all the cesium-137, most of the strontium-90 and cobalt-60, and some of the sodium have been adsorbed near the point of release to the earth, but very little tritium or chloride has been adsorbed.

Waste products discharged to the Snake River Plain aquifer spread out with a dispersion angle of about 90 degrees. This very wide angle causes considerable dilution of the wastes, and concentrations are rapidly reduced. Only a few waste products can be traced about 5 miles southward (downgradient) from disposal and cover about 15 square miles. Dilution, adsorption, and radioactive decay tend to retard the southward movement of the waste products and reduce the concentrations to about background levels.

2.2 Study of Possible Waste Migration from NRTS Burial Ground

A project was initiated to determine the influence of hydrogeologic factors on the possible migration of waste radionuclides at the NRTS solid waste burial ground. Test drilling and coring will be used to determine the subsurface conditions at the burial ground, to detect migration of radionuclides, and to collect geologic and water samples. The drilling started in June 1971. By the end of the year, two 640-foot wells were completed with multiple casings and sealed by pressure cementing. Two other wells were about half completed. All four of these wells were located outside the burial ground.

The information from these wells indicates the presence of two unconsolidated sedimentary beds that probably extend under the burial ground. These beds were encountered in all four wells, north, south, east, and west of the burial ground. The "110-foot" bed ranges in thickness from a few inches to approximately 20 feet and the "240-foot" bed ranges in thickness from approximately 5 to 30 feet. Three deeper but thinner and less continuous sedimentary beds were also found in at least three of the wells. Geophysical well logging, radiometric, chemical, and hydrologic tests have been made.

2.3 Big Lost River Floods at NRTS

A system analysis of flood routing of the Big Lost River at the NRTS has been developed by P. H. Carrigan, Jr., Washington, D. C. A digital computer model routes flows through various river sections and predicts the magnitudes of rare catastrophic floods and their effects on the NRTS. The present flood-control system can safely handle the maximum 55-year flood (3350 cfs) but not higher flows. A maximum 300-year flood (5300 cfs) would not overtop the diversion dam if the capacity to the diversion areas were doubled. Other methods of improving flood control are discussed.

2.4 Electrical Resistivity Profile Across the Snake River Plain

A deep geoelectric resistivity line from Blackfoot to Arco across the Snake River Plain was completed in August 1971 by the Regional Geophysics Branch in Denver, Colorado. The resistivity line was used to estimate the thickness and type of rocks and the geologic structure several thousand feet below the plain. The cross section indicates that across the southern part of the NRTS the approximate thickness of basalt ranges from 2000 to 7000 feet and the depth to the older "basement" rocks below the surface of the plain is about 12,000 to 16,000 feet. Thick beds of sedimentary rocks and/or silicic volcanic rocks which average 10,000 feet in thickness are indicated between the basement rocks and the basalts.

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P. H. Carrigan, Jr., *Probability of Exceeding Capacity of Flood-Control System at the National Reactor Testing Station, Idaho:* IDO-22052, U. S. Geological Survey open-file report: (in press).

J. B. Robertson, R. Schoen, J. T. Barraclough, *The Influence of Liquid Waste Disposal on Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970:* (in review).

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VIII. AIR RESOURCES LABORATORIES FIELD RESEARCH OFFICE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U. S. DEPARTMENT OF COMMERCE

(C. R. Dickson)

1. RESEARCH AND DEVELOPMENT PROJECTS

1.1 Building Wake Turbulence and Diffusion

The effect of building structures upon downwind diffusion rates has been examined in wind tunnels, theoretically (in very simplified manners), and in very limited instances by full scale measurements in the atmosphere. A knowledge gap exists concerning the effect of structures during temperature inversion conditions and very light, meandering wind speeds. Very practical information is needed about both the magnitude of this effect and the conditions (building size, minimum wind speed, etc) at which building wake effects vanish. To answer some of these questions, a simple, rectangular-shaped solid structure of hay and straw (the most economical way known to fabricate a semichangeable structure) was erected at the apex of the Grid III diffusion grid. Bidirectional vanes, cup anemometers, and temperature sensors were placed upgrid and downgrid of the structure to observe longitudinal and vertical profiles of wind and temperature. The basic field testing program consisted of measuring the downwind effluent concentrations directly and comparing them with the diffusion climatology of the test grid developed in previous years. From these direct measurements, the magnitude and downwind extent of the structure influence were determined.

The field testing site consisted of a sampling grid with a 16 x 8 x 8 meter structure centered at the apex. The sampling grid was 120 degrees wide and opened toward the south-southwest. High volume air samplers were positioned on arcs at 4 degree intervals at 1 meter above the ground. The grid had sampling arcs at radial distances of 25, 50, 100, 200, and 400 meters. Vertical samples were available at 4, 8, and 12 meters above the ground (1/2, 1, and 1-1/2 building heights) at positions on the 25, 50, and 100 meter arcs. Seven vertical sampling profiles were available at the 25 meter arc, covering a lateral span of 60 degrees. At 50 and 100 meters downwind, single vertical sampling profiles were measured downgrid from the central vertical sample profile on the 25 meter arc (the center line established for the sampling grid).

Initial measurements have shown the development of building wake dilution and its apparent downwind extent. The continuing series of tests will examine the generality of these effects, the mean and extreme differences between concentrations within and outside of the wake, the downwind extent of the wake diffusing regimes, and relationships between the size of the obstacle and meteorological conditions and either the distance or time locations of transitions to successive diffusing regimes.

1.2 Urban Influence on Nighttime Airflow Estimated from Tetroon Flights

Constant-volume balloon (tetroon) flights tracked by radar across Columbus, Ohio, illustrate the effect of a city on the nighttime airflow at heights of 100 to 200 m. On the average, the urban influence on wind direction is small at a height of 100 m, but an anticyclonic turning of 10 degrees is observed at 200 m. The anticyclonic turning is greater under inversion than under lapse conditions and greater after midnight than before; it appears to result both from an increase in the frictional force due to increased vertical mixing and from a mesoscale high pressure system formed aloft as the result of the warmer temperatures within the city. The decrease in wind speed across the city averages nearly 20% of the upwind speed under lapse conditions but is very small under inversion conditions. In both cases the region of maximum deceleration tilts downwind with height. The average upward air motion exceeds 4 cm sec^{-1} above the downtown area under light wind conditions, and increases to 1 m sec^{-1} as the wind speed approaches 20 m sec^{-1}. In the case of strong winds, alternating regions of upward and downward motion occur downwind of the city.

1.3 Three-Dimensional Air Trajectories in the Planetary Boundary Layer of the Los Angeles Basin Determined from Tetroon Flights

One hundred and five constant-volume balloons (tetroons) were released from various sites in the Los Angeles Basin for the purpose of obtaining 3-dimensional air trajectories in the planetary boundary layer of the Basin. The tetroons, with transponders attached, were tracked by an M-33 radar positioned atop Mt. Thom, 5 km north of Glendale. In general, the tetroons at heights of a few hundred meters tended to move slowly westward between midnight and sunrise, slowly northward between sunrise and noon, and rapidly eastward between noon and sunset. Tetroons launched from Redondo Beach and the Long Beach area during the day distinctly show the convergence zone extending northeastward from the Palos Verdes Hills due to the confluence of sea breezes from west and south. Tetroons released near the downtown area around sunrise tend to drift toward city center before moving northeastward into the Pasadena-Glendale area. During the day the tetroons oscillate through much of the depth of the mixed layer beneath the inversion, but at night the vertical oscillations are usually very small. The tetroon trajectories were compared with surface trajectories derived from the extensive surface wind network within the Basin, and it was shown that the ratio of trajectory separation distance to tetroon travel distance averaged about 0.2 during the day and 0.4 at night. Oxidant readings obtained by a helicopter following along the tetroon trajectories were compared with fixed-point readings and it appeared that, downwind of the city center, most of the increase in oxidant during the day was due to photochemical effects on individual volumes of air and was not due to advection of previously existing high values of oxidant into the area.

1.4 Mesoscale Transport Studies

The wind field analyses, from the 21 station network of wind towers over the upper Snake River Plain, were used to produce a series of LOFT-release trajectory plots for the entire year of 1969. The computational and graphical techniques were the same as for the PBF trajectories done previously. The two release periods selected for the LOFT trajectories were 0800 to 2000 MST and 2000 MST to 0800 MST, which conform approximately to release periods anticipated for the LOFT tests. The minimum time for carrying particles remaining on the computational grid was set at 12 hours which allowed the first particle released to travel up to 24 hours.

As one would expect, there were several differences in the LOFT trajectory patterns and PBF trajectory patterns due to the differences in the positions of the release points with respect to the boundaries of the computational grid. However, the primary differences in the trajectory patterns seemed to be caused by the difference in the positions of these two locations with respect to the large circular shaped eddy which forms occasionally northeast of the test site. Particles released from the LOFT area were more frequently caught in this closed circulation pattern than particles released from the PBF area. The material was held in the eddy for periods of 10 to 30 hours.

1.5 Mesoscale Receptor Climatology

A wind and transport climatology was developed for the LOFT site with the general aim of determining what is a necessary and practical climatology for use as guidance in reactor siting. In the specific application to the LOFT facility, the question of where to locate was altered to the question of what would be the relative risks to surrounding areas once a location is determined.

The hourly wind records for a five year period were summarized to give wind roses by time of day and season of the year. Frequencies of wind reversals were recorded with respect to time of day, which at the LOFT facility were about 95% of the time due to the normal diurnal wind pattern as opposed to the effect of synoptic scale weather patterns. Daily probabilities of maximum winds exceeding certain speeds out of specified quadrants were recorded with respect to 24-hour days and 9-hour work days.

From the aforementioned trajectory plots, a climatology was developed to determine frequency of transport to grid squares in the computational area. As already mentioned, the results were stratified according to time of release, ie, day or night. The statistics gathered were the count of trajectories reaching the target area, which gives the relative probability of any random release hitting any specific target; the total number of trajectory counts, which when compared to the first statistic gives the relative dwell time at the target; and the counts by days for any trajectory reaching the target, which gives the daily probability of a hit at a target.

As might be expected, a contouring of results showed a major SW-NE axis in accordance with the two principal wind directions; however, an interesting deviation was a pronounced maximum to the east of the LOFT facility in accordance with the aforementioned circular eddy that commonly forms east of the NE corner of the NRTS.

1.6 Climatology of Diffusion Classes at CFA

A diffusion climatology was developed in accordance with guidelines from the AEC Division of Reactor Licensing. The data were tabulated as a frequency of cases. These cases were stratified according to location of measurement (eg, CFA or Grid III), height of the lowest temperature measurement (2 meters or 10 meters), hour of the day, direction of the wind, speed class of the wind, and vertical temperature gradient class. There were 19 direction classes, 18 classes of 20 degree sectors, and a "calm" class. There were 8 speed classes including "calm", and 6 classes of vertical temperature gradient.

The principal result was to verify the existence of a large number of cases when winds were 2 miles per hour or less and the vertical temperature gradient was that of a strong inversion, ie, greater than or equal to 4°C per 100 meters. Thirteen percent of all CFA hourly data were in this category when the temperature from the 2 meter level was the lowest height of temperature measurement. This figure was reduced to 8% using 10 meters as the lowest height of temperature measurement.

1.7 Diagnostic Analysis of Wind Fluctuations through Energy Spectra Comparisons

Comparison of wind speed and component spectra for a given location over long time periods has shown that marked differences can occur. It was demonstrated that, for a wind represented by a simple sine wave, about 80% of the eddy energy of the velocity function appeared in the energy of the mean speed and almost all the remaining 20% appeared in the speed spectra at twice the frequency at which it appeared in the velocity spectra. The differences were of a physical as well as a mathematical nature and became important when the variation in the wind direction was through as much as 180 degrees. The comparison of the speed and component spectra was used to determine the nature of velocity variation in the different frequency bands of the spectrum. If the energy in a given frequency band of the speed spectrum was significantly less than the energy in the same band of the combined component spectra, then the velocity variations for this frequency band involved direction reversals. If there was little difference between the two types of spectra, for a particular frequency band, then the velocity variations in this band were primarily speed fluctuations.

Another comparison technique used to provide insight into the nature of velocity variation involved examination of the changes in the individual component spectra as the coordinate axes, upon which the components were defined, were rotated. The principal axes of oscillation for the entire spectrum or for individual frequency bands can be determined from this technique. There is also a better opportunity to find the physical causes involved with the type of information about the kinematics of the velocity variation provided by these techniques.

The comparison technique described above was used to substantiate the startling phenomenon of the wind blowing in opposite directions at two levels on a wind tower, observed on several occasions at Grid III at the NRTS. Comparisons of the wind speed and component spectra for a data sample of one year in the CFA area clearly showed a diurnal reversal of the wind direction at the 76 m level but only a speed fluctuation at the 6 m level. This indicated that the strong low-level shear, apparently topographically induced, was a fairly common occurrence. This phenomenon had important implications for hazard analysis because the direction that material would travel from a release point would depend on the elevation of the release, eg, a door or a stack.

The rotational technique described above was used to determine the principal axis of the diurnal oscillation. It was found to be rotated 49 degrees from north, which parallels the mountain barriers on either side of the upper Snake River Plain.

1.8 Comparisons among Tracer, Tetroon, and Wind-Field Derived Trajectories and Some Diffusion Estimates

A number of simultaneous measurements were made to better understand transport, diffusion, and plume depletion affecting airborne material carried to distances of about 100 kilometers and for time periods of many hours. A chemically inert gas, methyl iodide tagged with radioiodine, was continuously released over periods of approximately one hour in length from a 250-foot stack. Air sampling arcs were positioned approximately 6, 19, 48, and 80 kilometers downwind. Transponder-equipped tetroons were released at 15 to 20 minute intervals during the tracer releases and were tracked with an M-33 radar. Tower-mounted wind sensors recorded the wind directions and speeds at a network of locations within the encompassing 4800 sq mile area. The winds measured within the network were used to calculate low altitude trajectories. The positions of the plume center lines determined from air sampler data, tetroon trajectories, and wind field derived trajectories compared favorably.

Arc-by-arc examination of peak sampled concentrations versus downwind distance showed a rate of dilution less than expected from an extrapolation of shorter distance measurements. The implication of slower than expected rates of dilution is important and needs thorough examination.

1.9 Low Wind Speed Studies

For the reporting period, wind velocities and temperatures were measured at a number of levels on the 200-foot Grid III tower. These measurements were recorded day and night at ten second intervals in order to study such things as the frequency and duration of the low wind speed episode and the depth of the low wind speed layer. It has also become apparent that very often, under low wind speed conditions, there were marked differences in wind direction at different levels on the tower. Research is continuing on the relationship between the directional wind shear in the vertical and the temperature gradient.

1.10 Nuclear Reactor Evaluations

Work is continuing with the Division of Reactor Licensing, AEC Headquarters, to develop a general computer model to be used in evaluating potential hazards from nuclear reactors. The model calculates simulated accident and annual average atmospheric dilution factors for effluents, using data supplied in the Safety Analysis Reports for each reactor being built or proposed in the United States.

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G. E. Start, C. R. Dickson, P. G. Voilleque', "Comparisons among Tracer, Tetroon, and Wind Field Derived Trajectories and Some Diffusion Estimates", *Proceedings* of Air Pollution, Turbulence and Diffusion Symposium, Las Cruces, New Mexico, December 1971 (in press).

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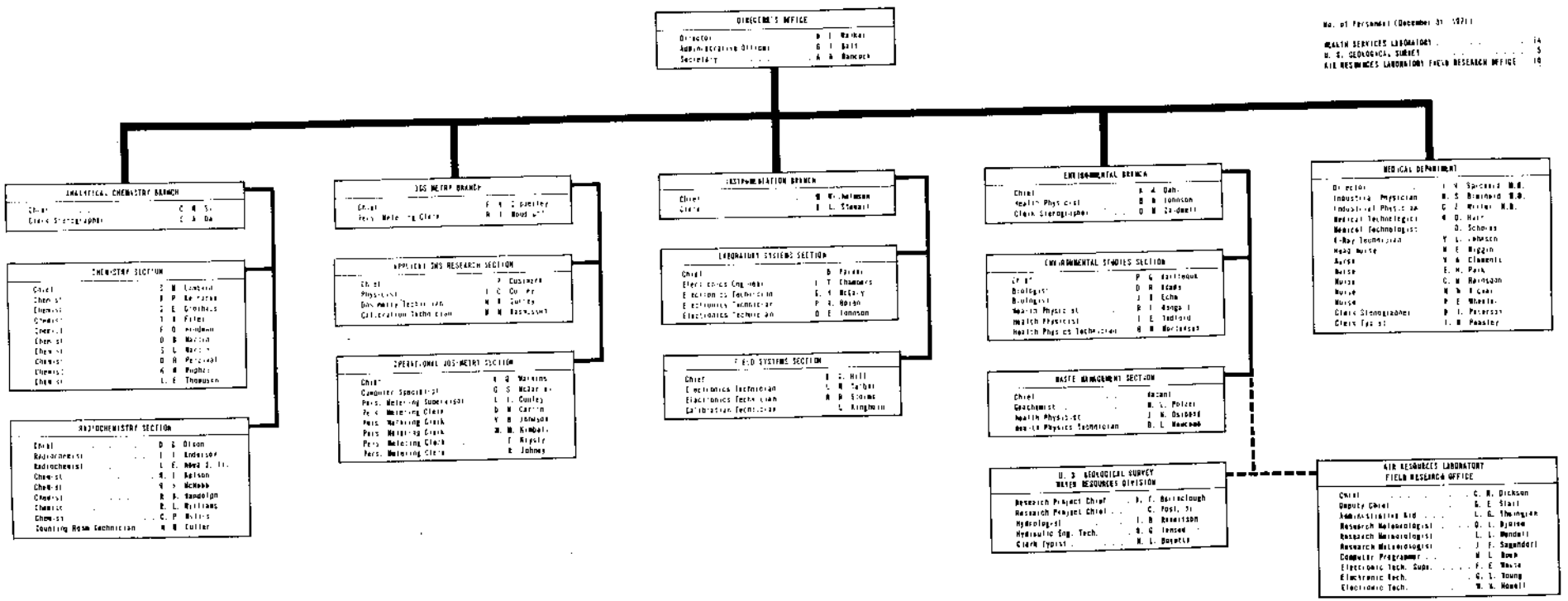
APPENDIX - ORGANIZATIONAL CHART OF THE HEALTH SERVICES LABORATORY

HEALTH SERVICES LABORATORY



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