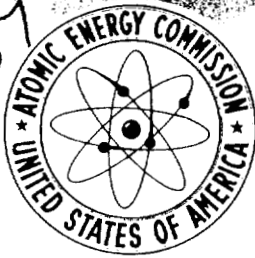


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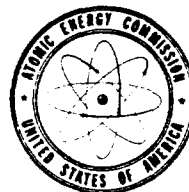
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1968
ANNUAL REPORT
OF THE
HEALTH SERVICES LABORATORY

George L. Voelz, M. D.

DIRECTOR



UNITED STATES ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
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PREFACE

It is a great pleasure for me to publish this report on the activities of the Health Services Laboratory for 1968. The Laboratory was organized in May 1967 from six branches of the Idaho Operations' Health and Safety Division. Its primary function is to develop a technical staff in occupational medicine, health physics, radiological dosimetry, analytical chemistry, and instrumentation, which can support the occupational health programs at the U.S. Atomic Energy Commission's National Reactor Testing Station (NRTS), Idaho. Two other federal agencies, U.S. Geological Survey and Environmental Science Services Administration, have professional staffs that conduct research studies for the AEC at the NRTS. These groups are administered through and work closely with our Laboratory personnel.

This report outlines a number of significant contributions that the Laboratory has made in various areas of radiological science and occupational health. It reflects a gradual increase in the range of our research and development projects, particularly in dosimetry, environmental monitoring, analytical chemistry, and in vivo counting technology.

In late 1967, the AEC Division of Compliance requested certain analytical chemistry and dosimetry services to aid their evaluation of environmental studies at various licensee plants throughout the United States. This program, now entitled the Independent Measurements Program, appeared in several areas of our work during 1968 and will continue to receive increasing attention in the future.

It is my hope that this report summarizes the work of the Health Services Laboratory staff in an accurate and useful way. Comments on our report are most welcome and we would invite you to exchange viewpoints on particular projects that may be of interest to you.

George L. Voelz, M. D.
Director, Health Services Laboratory

March 1969

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1968 ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

I. INTRODUCTION

The Health Services Laboratory is composed of five branches: Analytical Chemistry, Dosimetry, Environmental, Instrumentation, and Medical. The U.S. Geological Survey and Environmental Science Services Administration's (ESSA) Air Resources Laboratories Field Research Office maintain offices at the NRTS which also are administered through the Health Services Laboratory. The organization and the staff of the Laboratory are indicated in the Appendix at the end of this report.

There were no major organizational changes during 1968. As of December 1968, the staff totaled 76 persons, including 51 professional staff members, 19 technicians, and 6 administrative and clerical personnel. In addition, the U.S. Geological Survey and the ESSA groups employ 5 and 13 people, respectively. The Laboratory staff was increased by 5 persons during 1968; the additions were primarily in the Analytical Chemistry Branch to do the additional work created by the Independent Measurements Program.

The Laboratory organization contains the feature that all personnel performing research and development work also bear responsibilities for routine operational programs in their specialty. This feature of the organization leads the research programs to be tied closely to operational problems. It has the advantage of stimulating innovations in the operational functions of the Laboratory and tends to shorten the time between the development of new techniques and their application in the NRTS health and safety programs.

The primary task of the Laboratory is to support the NRTS operations in the conduct of occupational health programs. Most of the NRTS operational programs in industrial medicine, personnel dosimetry, portable health physics instrumentation supply and maintenance, environmental monitoring, analytical chemistry, and whole body counting are performed by Laboratory personnel. The Laboratory budget includes about 16% of its support from the AEC Division of Biology and Medicine for specific research and development work. The remainder of the Laboratory activity is supported by operational funding for the NRTS.

The operational activities of the Laboratory are covered in a very superficial fashion in this report. The work performed in special support activities at the NRTS and in research and development projects received greater attention since this work is generally of greatest interest and value.

II. MEDICAL BRANCH

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

Occupational medical services at the NRTS are provided through an organizational system which is unique to U.S. AEC medical programs. The AEC Medical Branch is responsible for the planning, operation, and direction of this program for NRTS contractors as well as AEC personnel. This medical system is complicated by the fact that several different companies serve under Operations Offices other than the Idaho Operations Office. An effective program is maintained because of the rapport established between parent company medical departments and the AEC Medical Branch plus the acceptance of this program by the local contractor managements.

1. ROUTINE MEDICAL ACTIVITIES

The Medical Branch provides an occupational medical service that includes physical examinations (preplacement, periodic, termination, and special), diagnosis and treatment of occupational illnesses and injuries, emergency or short-term treatment of nonoccupational illnesses and injuries, and consultation with contractors and employees on health problems. Complete medical records are kept of all patient visits at the NRTS dispensaries. In the past, medical recordkeeping was complicated by the use of multiple types of company medical forms for each contractor. Improvements in the medical record system in the past several years have resulted in the acceptance of a standard preplacement and periodic physical examination form by the majority of NRTS contractors.

The preplacement questionnaire, which has been in use for two full years, has been of benefit in determining employability and predicting restrictions for prospective employees. The use of addressograph plates continues to be an efficient method for identifying medical records and request slips and for reproducing recurrent reports. Microfilming of inactive charts is still performed annually; a duplicate record is sent to CF-690 for storage as a protection against loss or fire. New fire-resistant file cabinets were installed this year to protect our current medical records. Scheduling of patients for physical and periodic laboratory examinations is simplified by the use of computerized monthly reports that list individuals due for examination. Computer compilation

of data on the ID-13 industrial accident report continues to be a satisfactory method of retaining and reproducing accident and injury data.

Approximately 4,000 examinations for internal radioactivity have been made on NRTS personnel in the Medical Van since it was first placed in operation in 1966. Significant personnel time is saved by performing these procedures in each plant area with a mobile unit. Blood and urine samples and chest X-rays are procured during the same visit as part of the periodic medical examination program. During 1968, Argonne National Laboratory elected to have whole body counts performed in the Medical Van at their plant location rather than at the Central Facilities counter primarily because of the time-saving feature. During the latter part of 1968, employees at the Naval Reactor Facility (NRF) received laboratory work and chest X-rays at the Central Facilities Dispensary rather than in the Medical Van since a reduced amount of physician time available at NRF required the physical examinations to be performed at Central. The whole body counting program at NRF is still performed in the Medical Van.

2. SUMMARY OF 1968 MEDICAL BRANCH WORK STATISTICS

2.1 Patient Visits to AEC Dispensary

Treatment visits at the AEC Central Facilities (CF) and Idaho Falls Headquarters (HQ) Dispensaries increased from 8,801 in 1967 to 8,956 in 1968 (Figure 1). The increase in number of Headquarters personnel is reflected in an increase from 18 to 25% of the total treatment visits being performed at the HQ dispensary. Only 3% of the visits were for occupational injuries or illnesses at Headquarters as compared to 18% at the CF Dispensary. Occupational visits decreased from 1,581 in 1967 to 1,258 in 1968 in spite of the increase in overall treatment visits. Total visits for all purposes decreased slightly from 12,226 to 11,964.

Treatment visits at AEC dispensaries during 1968 were distributed by employee as follows: Idaho Nuclear Corporation, 48%; Atomic Energy Commission, 24%; Phillips Petroleum Company, 13%; Westinghouse Electric Company, 6%; Argonne National Laboratory, 3%; construction contractors, 3%; other federal agencies, 2%; other, 1%. The distribution of visits by contractor was essentially

unchanged from 1967 with the exception of construction (6 to 3%), which reflects a decrease in construction activity at the NRTS; a corresponding increase in Westinghouse visits (3 to 6%) resulted from increased referrals to CF due to a reduction of physician visits to the Westinghouse (NRF) Dispensary.

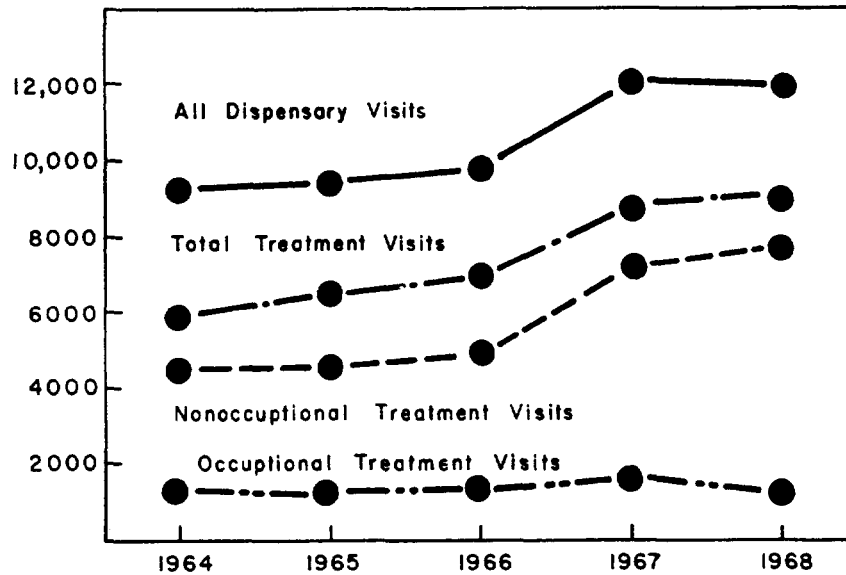


FIG. 1 CENTRAL FACILITIES AND AEC HEADQUARTERS DISPENSARY VISITS.

2.2 Patient Visits to All NRTS Dispensaries and First Aid Stations

There was a 4% decrease in total site dispensary visits in 1968 compared to 1967 (Table I). This occurred as a result of a 7% decrease in occupational treatment visits and a 20% decrease in occupational "other" visits while nonoccupational visits were unchanged. Only 14% of the treatment visits were for occupational injuries or illnesses.

2.3 Physical Examination Programs

As a result of a 45% drop in preplacement physical examinations in 1968, total examinations decreased from 2,531 in 1967 to 2,219 in 1968 (Figure 2). The number of periodic and termination examinations increased moderately.

TABLE I

1968 NRTS DISPENSARY VISITS

Dispensary	Occupational			Nonoccupational		Total
	Treatment Visits	Other ^[a]	Percent	Treatment Visits	Percent	
Central Facilities and Headquarters	1,258	3,008	36	7,698	64	11,964
Chemical Processing Plant	217	12	14	1,523	86	1,752
Argonne National Laboratory	310	87	16	2,187	84	2,584
Test Reactor Area	369	8	17	2,008	83	2,385
Naval Reactor Facility	1,664	2,043	26	10,410	74	14,117
Test Area North	212	58	13	1,760	87	2,030
First Aid	284	--	28	742	72	1,026
	4,314	5,216	27	26,328	73	35,858

[a] Other includes physical examinations, X-rays, clinical laboratory visits, urine samples for radiological analysis, and immunizations.

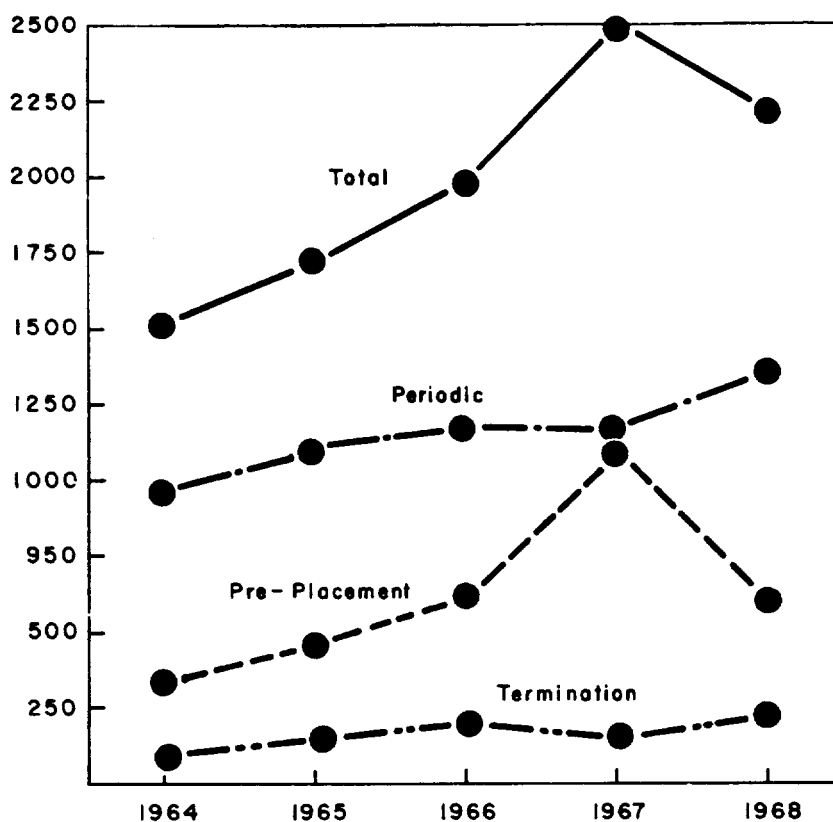


FIG. 2 PHYSICAL EXAMINATIONS PERFORMED AT THE NRTS.

2.4 Laboratory and X-Ray

Another result of the decreased number of physical examinations and dispensary visits last year was a 9% reduction in X-ray procedures and whole body counts. The decline in whole body counts during the past three years resulted from the lack of requests for special sampling of large groups and an increased interval for periodic counts for Idaho Nuclear Corporation. In addition to whole body counting, the Medical Van accounted for approximately 20% of the X-ray examinations and 25% of urine and blood collections. The routine evaluation of the Achilles Reflex Time Test was discontinued in August of 1968 and resulted in an additional reduction in total laboratory procedures (Figure 3).

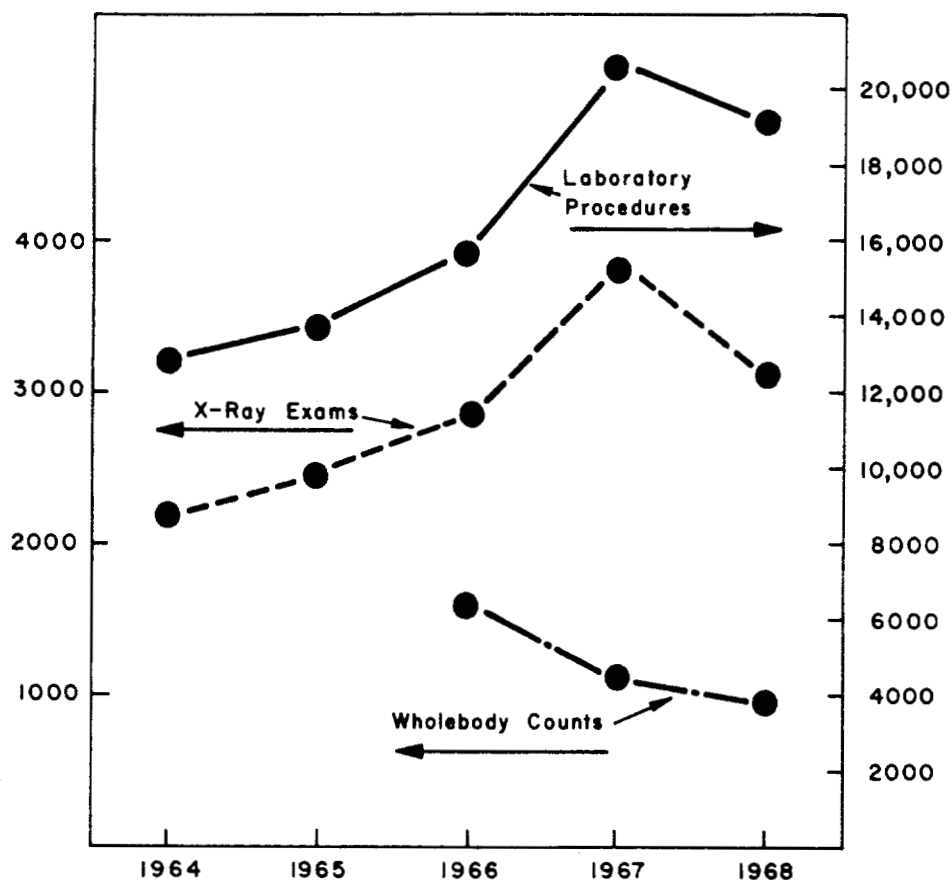


FIG. 3 X-RAY, LABORATORY PROCEDURES AND ROUTINE WHOLE BODY COUNTING.

III. DOSIMETRY BRANCH (F. V. Cipperley)

The major objectives of the Dosimetry Branch are to supply personnel radiation dosimetry service to the NRTS, maintain complete records of exposure doses, provide consulting and support service to contractors regarding dosimetry problems, and to perform research aimed at improvement of monitoring devices and systems.

1. OPERATIONAL DOSIMETRY ACTIVITIES

1.1 Summary of External Radiation Exposure Statistics

The Dosimetry Branch provided personnel dosimetry coverage for 6,754 regularly assigned persons during 1968 at an average rate of 5,000 persons per quarter. Coverage also was provided for 15,984 visitors. This involved the processing of 57,606 regular area exchange badges, 31,963 temporary badges, 1,603 regular badges at the contractor's request, and 10,650 miscellaneous badges, for an overall total of 101,822 badges of all kinds. Approximately 10,000 of the regular badges processed were thermoluminescent (TLD) dosimeters. Only 80, or less than 1%, yielded positive readings. Approximately 98% of the monitored personnel received an annual accumulated exposure of less than 3 rem; about 2% received between 3 and 5 rem; only one person received more than 5 rem during the year.

The total recorded radiation exposure for NRTS personnel in 1968 was 1,781 rem. The average annual accumulated exposure of 264 mrem per person compares favorably with the current 10-year average of 319 mrem per year.

1.2 Summary of Internal Radiation Exposure Statistics

Results obtained by the Analytical Chemistry and Medical Branches on 2,595 urinalyses and 1,695 in vivo whole body counting measurements on humans were recorded and tabulated. Although some statistically significant activities were found, all were well below one-half the maximum permissible body burden for the particular isotope.

1.3 Program Improvements

In January of 1967, thermoluminescence (TLD) personnel dosimetry for low-exposure-risk personnel was instituted. During the fourth quarter of 1967, 2,546 persons utilized TLD with only 46, or less than 2%, receiving any detectable exposure. In July 1968, the monitoring period for approximately two-thirds of the persons using TLD dosimeters was extended from three to six months. The capability of TLD's to accumulate low-exposure doses over extended time periods and the ability of the contractor health physicists to forecast personnel exposure potential had been demonstrated sufficiently to warrant this extension of the monitoring period.

During 1968, a duplicate area exchange badge system was initiated. This system permits the physical servicing of the badges to be done by security personnel in the gatehouses on night or weekend shifts. Fresh badges are delivered to and exchanged at the areas, and the used badges returned to the Laboratory by security personnel. This procedure eliminates the time and expense previously required of Dosimetry Branch personnel.

A system also was initiated whereby used visitor badges from all areas are delivered to the Laboratory and fresh badges returned to the area by security roving patrol. This eliminates the time and travel costs previously incurred by Dosimetry personnel performing this function.

The Dosimetry Branch participated in the recertification program of the National Sanitation Foundation and was certified for the second consecutive year to use the NSF Seal of Approval.

One method of measuring the overall efficiency of the personnel monitoring program is to determine the number of persons furnished dosimetry service per Dosimetry Branch employee. This figure is derived by dividing the average number of persons furnished personnel monitoring service by the number of dosimetry personnel, technical and supervisory, involved in providing the service. Figure 4 presents this data for the period from 1958 through 1968. Automation and improvements in the dosimetry systems have increased the services provided per employee by more than a factor of five since 1958.

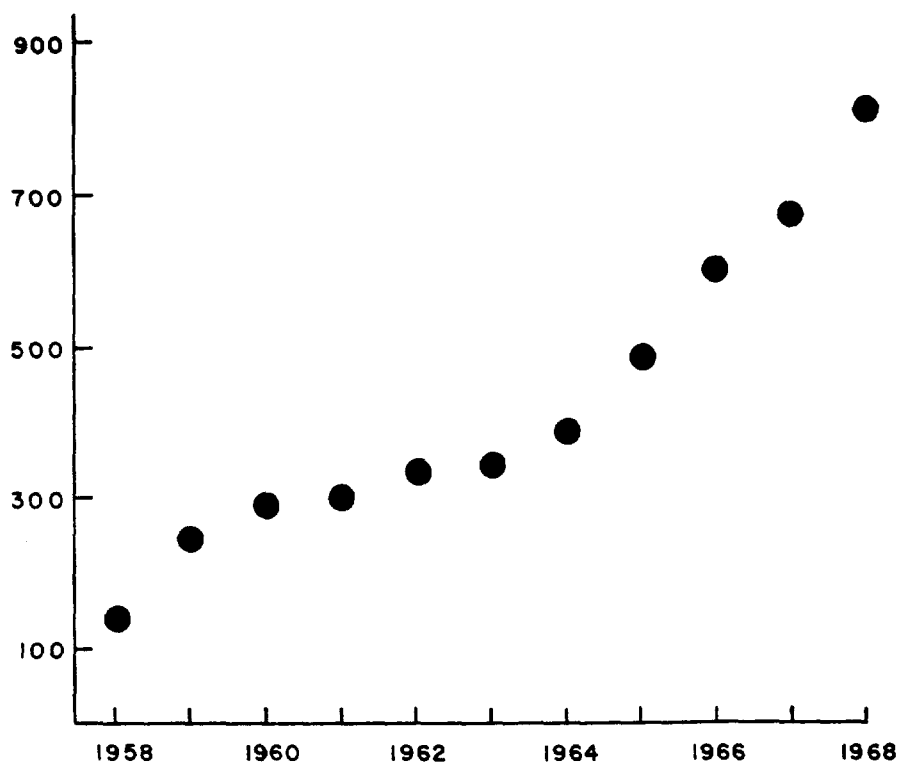


FIG. 4 PERSONS MONITORED PER OPERATIONAL DOSIMETRY EMPLOYEE.

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 10^6 R, and neutron dose calculations at five energy levels. Various thermoluminescent and radiophotoluminescent materials, as well as activation foils and dosimetric films, are utilized to support the AEC contractors in performance of special problem dosimetry. Calibration capabilities include 5 through 220 keV monoenergetic X-ray, 0 through 250 kVp filtered X-ray, radium, cesium, cobalt, and americium-beryllium sources. Calibrations are checked for special purity with a semiconductor-detector spectrum analyzer and for correct exposure with free air ionization chambers.

2.1 High-Level Gamma Measurements

Support was provided various contractors in the performance of high-level gamma dose measurements such as: hot shop instrumentation dosimetry

measurements at the Experimental Breeder Reactor-II area; gamma-heating measurements at the Advanced Test Reactor area; dose-rate determination in high-level radiation areas at two off-site locations; and measurement of doses in the 10^6 R range to transducers located beneath the reactor core at the Special Power Excursion Reactor Test area. This support was to provide and to evaluate lithium fluoride and calcium fluoride dosimeters, including high-level gamma calibrations in the multikilorad range. Thermoluminescent dosimeters and dosimetry film packets were utilized in assisting Idaho Nuclear Corporation perform gamma-dose measurements in the Advanced Test Reactor flue system and for in-core gamma-dose measurements at the Engineering Test Reactor.

2.2 Neutron Dose Determination

Measurement of the neutron dose profile at the FRAN reactor was performed utilizing the newly designed Personnel Neutron Threshold Detectors. Doses were calculated at the following energy levels: 0 to 0.4 eV, 0.4 to 2 eV, 2 eV to 1 MeV, 1 to 2.9 MeV, and 2.9 MeV and greater.

2.3 TLD-Film Comparison

Special thermoluminescent dosimeter retainers were designed and fabricated to fit the dosimetry badge used at the Nuclear Rocket Development Station. These were used for a film versus TLD comparison test performed for the Space Nuclear Propulsion Office at the Nevada Test Site. The comparison was conducted over two three-month periods from June through December 1968. Findings from the test have resulted in ID furnishing TLD personnel dosimetry service for some 600 to 800 SNPO employees beginning January 6, 1969.

2.4 Radiation Damage Study

Assistance was provided Phillips Petroleum Company in measuring gamma and neutron exposures in the area within the primary reactor shield at the Connecticut Yankee Power Reactor. The purpose was to study radiation-induced damage to reactor components, such as electric motors, insulation, and valve packing.

3. RESEARCH AND DEVELOPMENT PROJECTS IN DOSIMETRY

3.1 AEC Independent Measurements Program. (J. P. Cusimano, J. C. Culley)

A study was made of the characteristics of various phosphors to determine a suitable material for measurement of environmental exposure due to radioactive effluents from privately operated nuclear installations. Environmental surveillance presently is being accomplished at three licensee plants in support of the Independent Measurements Program for the AEC Division of Compliance.

3.2 Personnel Neutron Threshold Detectors. (J. C. Culley, V. D. Watkins)

Studies were begun in 1965 to develop a dosimeter that can be easily worn by personnel and that contains an array of activation foils to determine the neutron spectrum and flux to which it has been exposed. The present NRTS system requires the spectral information provided by a primary fixed dosimeter located in close proximity to the criticality source in order to calculate the dose to the individual.

Calibration and evaluation of various foil configurations were performed utilizing the Health Physics Research Reactor at Oak Ridge and the neutron irradiation facilities at the Materials Testing Reactor and Experimental Breeder Reactor-I. Design was finalized and the units were ordered from a commercial supplier in December. The new devices will greatly increase the capability of spectral energy determination of neutron fluxes.

3.3 X-Ray Facility Development. (J. P. Cusimano, J. C. Culley)

Materials were selected, optimum thickness was determined, and K-fluorescent targets were fabricated for the production of discrete-energy X-rays.

An automatically timed shutter was designed, fabricated, and installed on the 250 kVp X-ray generator. The new shutter will provide precise timing of X-ray exposures for calibration and experimental use.

3.4 Phosphor Evaluation. (J. P. Cusimano)

An evaluation of dysprosium-doped calcium fluoride was performed to determine sensitivity, dose response, accuracy, and reproducibility. It was determined that gamma exposures as low as 4 mR could be routinely measured with a maximum spread of ± 1 mR.

The fading characteristics of manganese-doped calcium fluoride microrods were investigated and a preliminary equation to predict the decay rate was formulated.

3.5 Electronic Data Processing. (V. D. Watkins)

Considerable effort was expended in the attempt to interface a magnetic tape transport with the automatic film reader. Internal circuitry problems in the interfacing unit have hampered this project. Computer programs were completed for the film data acquisition system. Computer programs were finalized for analysis of environmental surveillance TLD data, including data reduction and statistical analysis for use in the Independent Measurements Program. Computer programs also were prepared to integrate segments of spectrum curves and to assist in the analysis of neutron-activation data.

4. PUBLICATIONS

1. J. P. Cusimano and F. V. Cipperley, "Personnel Dosimetry Using Thermoluminescent Dosimeters", Health Phys., 14 n 4 (April 1968) pp 339-344.
2. J. P. Cusimano, F. V. Cipperley, J. C. Culley, Special Applications of Thermoluminescence Dosimetry, IDO-12068 (June 1968).
3. J. P. Cusimano, F. V. Cipperley, J. C. Culley, "Applied Thermoluminescence Dosimetry Program at the NRTS", in J. A. Auxier, K. Becker, E. M. Robinson (eds.), Proceedings of Second International Conference on Luminescence Dosimetry -- Held at Mountain View Hotel, Gatlinberg, Tennessee -- September 23-26, 1968, CONF-680920 (September 1968) pp 722-736.

IV. INSTRUMENTATION BRANCH (M. Wilhelmsen)

1. ROUTINE INSTRUMENTATION ACTIVITIES

1.1 Field Instrumentation Maintenance

A pool of portable radiation survey instruments is maintained by the Instrumentation Branch for use by all NRTS contractors. This pool contains approximately 1,350 instruments of 17 types. These instruments are procured, repaired, and calibrated for use as required by the operating contractors. Some portable instruments that are procured by the contractors for special needs and specifications also are maintained in repair and calibration. During 1968, 2,788 individual repairs and calibrations were performed.

A radiation and weather data collection system consisting of 19 radiation stations and 2 weather stations, which telemeter data on a 24-hour basis to the Health Services Laboratory, is maintained by the Instrumentation Branch. These stations are at strategic locations on and around the NRTS up to 85 miles distance. The sensitivity of the system has been increased this past year to detect concentrations of $3 \times 10^{-13} \mu\text{Ci/cc}$.

1.2 Laboratory Instrumentation Maintenance

The maintenance of the Health Service Laboratory instruments is one of the major efforts of the Instrumentation Branch. The instruments range in complexity from an array of relatively simple scintillation-type well counters for gross gamma detection to multichannel and multiparameter spectrum analyzers. Nearly all of the instruments required maintenance during the year and some chronic offenders like the automatic liquid scintillation counter and the automatic low-beta detector were constantly giving trouble. Most maintenance problems are created by two general situations: (a) factory-induced problems due to poor design and construction of particular instruments and (b) operator-induced problems where proper operating procedures were ignored or not understood. Another facet of the maintenance load is the modification and adaption of equipment to perform functions not anticipated by the manufacturer or user at the outset. Analysers, tape transports, automatic changers, wound monitors, power supplies, spectrophotometers, and various other pieces of

equipment were modified. Some heavily shielded units weigh in the order of tons and have to be handled with special hoists and jacks.

2. SPECIAL INSTRUMENTATION SUPPORT ACTIVITIES

2.1 Freon Vaporizer Heater Apparatus. (P. R. Boren)

A Freon vaporizing apparatus was constructed for testing charcoal filters in the environmental chamber.

2.2 Interface Tape Transport to PDP-8/S. (K. H. McGary)

An interface unit was designed and constructed so a magnetic tape transport will operate through and in conjunction with a PDP-8/S data acquisition system.

2.3 Nitrogen-Flow Control for TLD. (K. H. McGary)

A nitrogen flow control was designed and built to be used in conjunction with a thermoluminescent dosimeter reader. The control automatically times the flow of nitrogen to correspond with the needs of the TLD unit. This regulation of flow saves significant quantities of nitrogen gas.

3. INSTRUMENTATION RESEARCH AND DEVELOPMENT PROJECTS

3.1 Aerial Monitoring System. (D. G. Hill, L. M. Talbot)

A prototype Portable Aerial Monitoring System has been designed and constructed to be used in conjunction with a radar unit operated by the Environmental Science Services Administration staff at the NRTS. The radiation analyzer utilizes a 3- x 3-inch NaI (Tl) scintillation crystal with a four decade logarithmic readout of 10^4 counts/sec. The analyzer output voltage signal is broadcast continuously from the transmitter in the monitoring aircraft to the receiver located in the radar unit. The readout from the receiver-discriminator is in analog voltage form. This signal is digitized and recorded with the aircraft position signals from the radar unit magnetic tape for processing by the Computer Center to show plots of the aircraft location and corresponding radiation readings. Components are on order and a new unit is being constructed to give greater transmitter range with increased detector sensitivity.

3.2 In Vivo ^{239}Pu Detection. (D. Parker, K. H. McGary)

The in vivo ^{239}Pu detecting system, under development throughout the year, is based on the utilization of custom-built proportional counters constructed according to design parameters established through a variety of research studies. Associated data acquisition equipment was assembled to accept pulses from the detector and process them statistically to show incremented composite averages of spectrum values. A standard background was subtracted from the composite thus effecting a degree of background reduction. Both anticoincidence and rise-time discrimination techniques were studied in an effort to determine the most effective method of separating pulses resultant from primary X-rays from those caused by incident high-energy interactions.

3.3 Horizontal Rotational Scanner. (D. Parker, P. R. Boren)

An improved horizontal rotational body scanner, Figure 5, was designed and constructed. The scanner provides the operator with a choice of six major

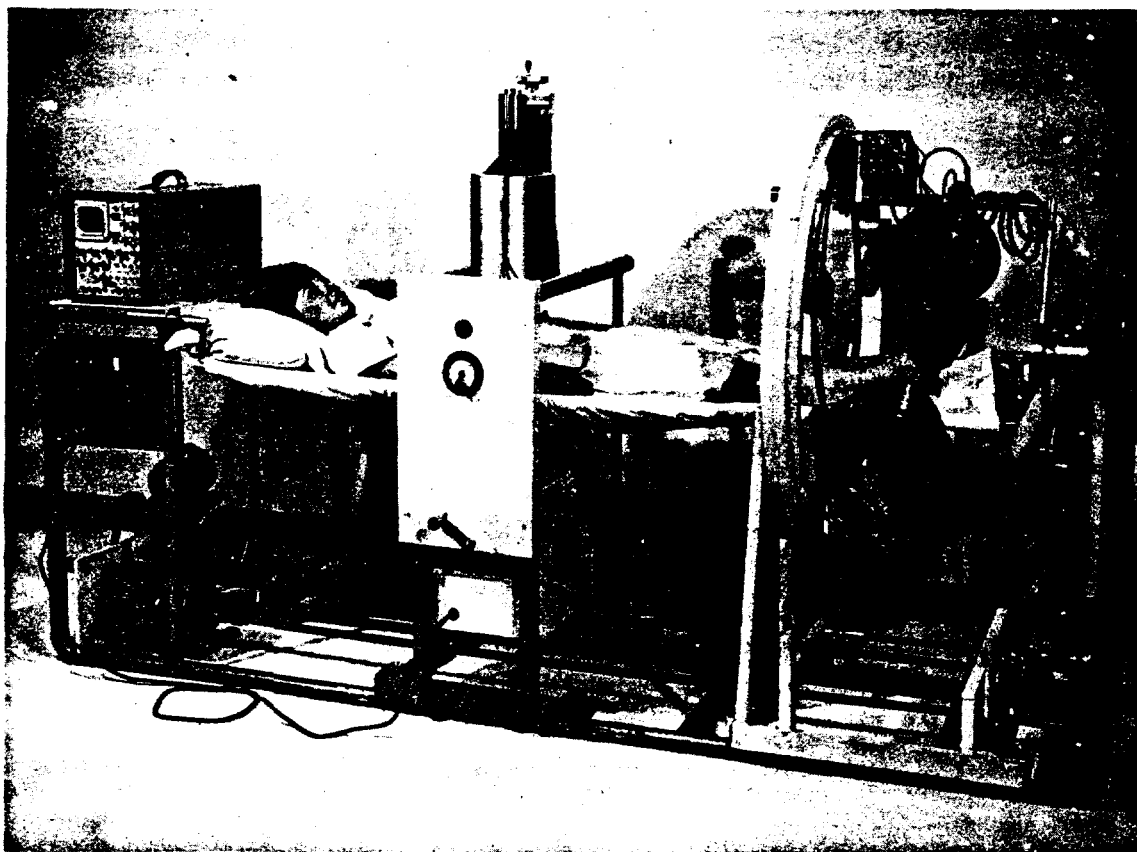


FIG. 5 HORIZONTAL ROTATIONAL BODY SCANNER FEATURES TWO 8 X 5 INCH NAI (TH) ROTATING DETECTORS (RIGHT) AND A RECTILINEAR SCANNER ACCESSORY (CENTER).

rotational speeds, six major longitudinal speeds, and a choice of easily mounted detectors. The complete unit was on display at the Health Physics meetings in Denver.

3.4 X-Y Scanning Attachment. (D. Parker, P. R. Boren)

A rectilinear scanning attachment, Figure 5, for the rotational scanner was designed and constructed. The unit provides a programmable scan of a selected portion of the human torso.

3.5 Automatic Changer for Radon Scintillation Cells. (M. Wilhelmsen, K. H. McGary)

An automatic changer was designed and constructed for counting radon scintillation cells. The changer holds eight cells and sequentially rotates each cell over a photomultiplier tube for counting. The changer can be preset by thumbwheel switches to count each sample respectively from one to nine times per cycle up to a total of six cycles. The count and time are preset on the associated scaler-timer with sample number, count, and time recorded on a printer.

4. PUBLICATIONS

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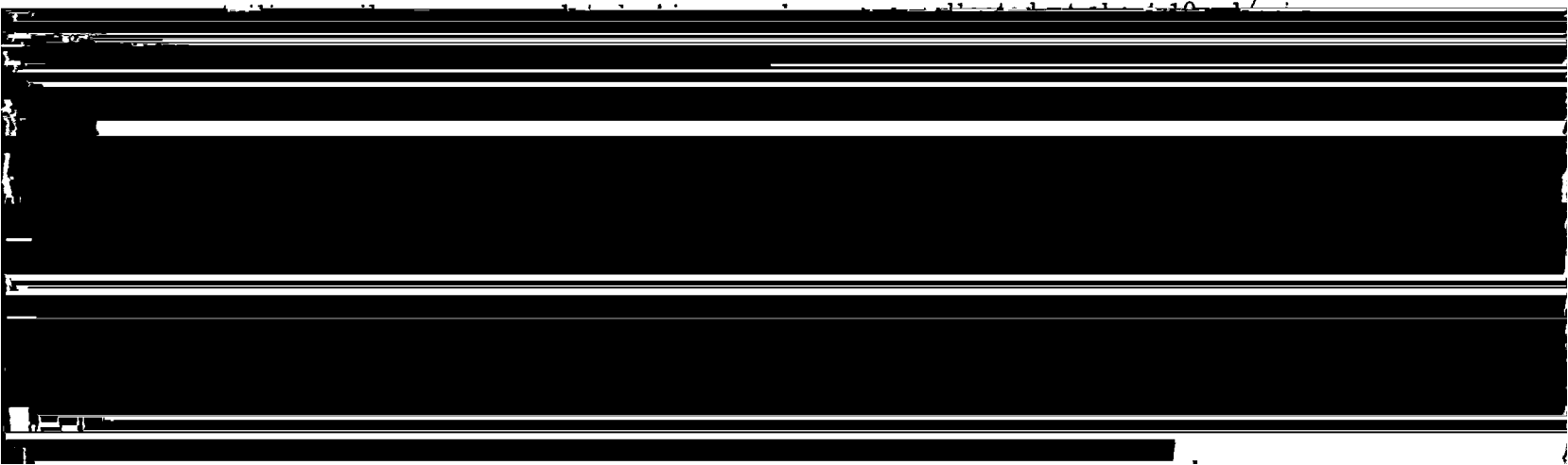
V. ANALYTICAL CHEMISTRY BRANCH (C. W. Sill)

1. ROUTINE ANALYTICAL CHEMISTRY ACTIVITIES

The Analytical Chemistry Branch of the Health Services Laboratory maintains the capability to provide chemical or radiochemical analyses for virtually any chemical element or radionuclide 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 recently inaugurated. This latter program involves an independent verification of the types and quantities of radioactive materials actually released to the environment by licensees operating a variety of reactor types and other nuclear facilities. During the past year over 20,000 analyses were made on some 14,000 samples of many different types, including direct in vivo measurement on humans. The analyses, most of which were made at extremely low levels, included most of the fission products, the transuranium elements, and the heavy element daughters of the naturally occurring series.

2. EVALUATION OF ^{222}Ra NEAR URANIUM TAILINGS PILES

In cooperation with the U.S. Public Health Service and the health departments of the states of Colorado and Utah, a one-year project to evaluate the public health aspects of atmospheric concentrations of ^{222}Ra in the vicinity of uranium



generally from 0.5 to 2 miles from the piles. Of the 44 off-piles stations, only two exhibited an average radon concentration above background equal to or higher than the 1 pCi/l screening value adopted for this study. The results indicate conclusively that there is very little, if any, hazard to the general public from this source.

3. RESEARCH AND DEVELOPMENT PROJECTS

3.1 Whole Body Counting Research. (J. I. Anderson, B. B. Barnett)

Rotational whole body counting was applied to improve the reliability of assessing radioactivity in man. Sixteen gamma ray spectra can be accumulated as the rotating detectors scan down the body. These spectra show the relative gamma activity in various sections of the body. By a computer technique, separate spectra are obtained as numerical data that are printed out in the spectrum shape. Another option for data reduction is to combine the 16 different spectra into a single isocount contour plot or isometric plot. The distribution of radionuclides in the body is thereby displayed with three coordinates: linear distance along the body, gamma energy, and the counting rate. Selected peaks from any of the spectra can be fit by a gaussian-type function to calculate areas under the peak and to determine their exact width and position on the energy scale.

Distribution of gross gamma activity in the body is determined by either helical or rectilinear scanning; the latter is used generally for more detailed determination of the distribution of activity over small areas. The data from both types of scans are reduced by a computer into isocount contours that show the distribution of the activity in the body by means of alphanumeric symbols. Another form of data display is to produce a continuous curve of the gross gamma activity along the entire helical path of the detector as it moves around the body.

Methods have been developed to determine the depth of deposition of a gamma emitting source in the body. A technique under investigation is based on the change in the ratio of integrated photopeak to the integrated counts in the entire spectrum. This ratio is expressed as a function of the depth of

deposition of the source. The ratio gets larger as the distance between the source and axis of rotation increases.

The capability has been developed for coincidence counting the annihilation radiation from positron-emitting nuclides. This technique can be used to determine the distribution of particulates tagged with positron emitters without resorting to a collimator. This technique should be applicable to studying the fate of particulates in the respiratory tract.

3.2 In Vivo Determination of ^{90}Sr by Analyzing Bremsstrahlung from the Skull. (D. G. Olson)

A method has been developed to directly measure in vivo ^{90}Sr in a human by determining the bremsstrahlung emitted from the skull (Figure 6). The technique minimizes the interference from other radioactive contamination, while the sensitivity for detecting ^{90}Sr in a 10-minute count is $0.03 \mu\text{Ci}$, which is only 1.5% of a maximum permissible body burden.

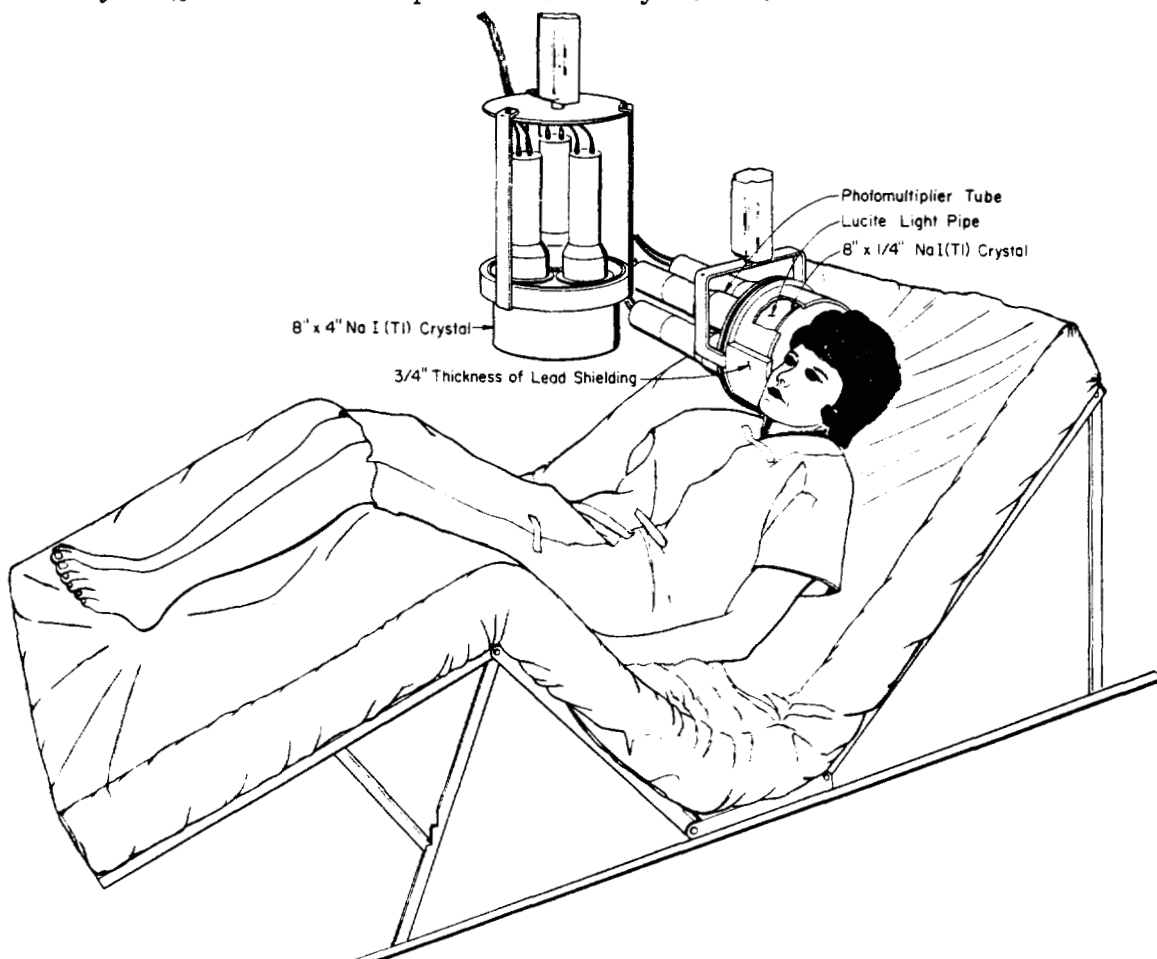


FIG. 6 COUNTING CONFIGURATION FOR IN VIVO DETERMINATION OF ^{90}Sr BY ANALYZING BREMSSTRAHLUNG FROM THE SKULL.

3.3 Alpha and Gamma Spectrometry. (C. F. T. Ching, B. A. Roberts, D. G. Olson)

A study has been undertaken to determine the best procedure for preparing alpha plates for spectrometry. Aspiration of the sample onto the plate gave more uniform deposition than evaporation but was not as good as electrodeposition. For those cases where solutions are carrier and salt free, evaporation of the tracer on microscope cover glasses yields resolutions comparable to electrodeposition. Electrodeposition is superior to other mounting techniques for practically all samples. The resolution of electrodeposited samples seems to be a function of the polish on the surface of the planchet where the deposition is made and the mass of the deposit.

A Ge(Li) detector with only 20 cc of volume was found to have a lower detection limit than an 8- x 4-inch (3,292 cc) NaI(Tl) crystal for counting samples where natural occurring elements are more abundant than the nuclide being sought. The good resolution of the Ge(Li) detector accounts for the increased sensitivity.

3.4 Analytical Procedure for Determining ^{35}S in Vegetation Samples. (C. P. Willis, C. W. Sill, D. G. Olson)

A study was made to measure the deposition velocity of sulfur dioxide tagged with ^{35}S on alfalfa. Several analytical problems that became obvious at the beginning of the project included: (a) how to collect and destroy the organic sample without losing the volatile $^{35}\text{SO}_2$, (b) how to use sufficient sample to give adequate sensitivity, and (c) how to count the 168 keV beta of ^{35}S .

A wet-ashing procedure was developed to decompose 30 g of vegetation with less than 5% losses. The separated barium sulfate is then counted in a suspension composed of liquid scintillation cocktail and ca-bo-sil. The detection limit for a 30 g sample was found to be 0.1 $\mu\text{Ci/g}$.

3.5 Development of a Clean Filter for Activation Purposes. (C. F. T. Ching)

Pursuant to the problem of finding a clean filter medium, an attempt was made to acquire materials of hydrocarbon or carbohydrate origin free of metallic ions. No satisfactory material has been obtained. Four different ultrapure graphites (> 99.9% carbon) were activated and found to have higher contamination levels than equal weights of high quality filter paper. Styrene monomer has been acquired and redistilled. Polymerizations have been made with commercial

catalysts, heat, and gamma radiation. The study will be completed to see if the polymer can be used to prepare a clean film.

3.6 Determination of In Vivo ^{235}U by Counting the Gamma Ray Activity from the Lungs. (L. E. Howard)

Uranium in the lung was determined by counting with a single 8-x4-inch crystal positioned over the lung. In a 40-minute count, the detection limit is 30 μg or 12% of a maximum permissible body burden.

3.7 Determination of ^{129}I by Activation Analysis. (C. F. T. Ching)

Iodine-129, a 1.6×10^7 year half-life radionuclide, is a fission product that contributes to the long-range buildup in the environment. Because of the low specific activity, a weak beta energy (150 keV), and a weak gamma energy (38 keV) of which 95% converts internally, giving rise to an even weaker (28 keV) X-ray, ^{129}I is extremely difficult to determine by a direct method. Activation analysis proves to be a practical way of solving this difficult analytical problem. The nuclear reaction, $^{129}\text{I} (n, \gamma) ^{130}\text{I}$, results in a 12.5-hour nuclide with a distinctive, 100% abundant, 669 keV gamma ray. By irradiating for 24 hours in a neutron flux of 1.3×10^{13} and using a combination of chemical and gamma spectrometric separations, ^{130}I has been isolated in an aqueous waste sample from a reactor retention basin. The major problem in the method is to isolate the ^{129}I from other atoms which have good activation cross sections. Solvent extraction followed by a precipitation gave satisfactory cleanup, but collection of the precipitate caused problems. One technique which proved valuable was to place a small polyethylene film inside the centrifuge tube. When the sample is centrifuged, the 1 mg of AgI collects on the film and can be removed for activation. Previous trials to remove the minute precipitate from the inside of a glass centrifuge tube or to filter the sample failed.

3.8 Determination of ^{55}Fe by Liquid Scintillation Counting. (B. B. Randolph)

A method was developed for the determination of ^{55}Fe by liquid scintillation counting or by measuring the 6 keV X-ray spectrometrically with either a proportional tube or a solid state detector. The ^{55}Fe method is needed to analyze waste samples from the dissolution of irradiated stainless steel clad fuels. Because ^{55}Fe has a comparatively long half-life, an abundant fallout from

thermonuclear detonations, and has biological significance in living matter, the nuclide is an interesting tracer. Therefore, a good analytical procedure is needed for such studies.

3.9 Determination of ^{90}Sr . (L. E. Thompson)

Strontium-90 in various media continues to be the major nuclide sought in the Laboratory. The method has been modified and shortened; however, an investigation is underway to see if ^{90}Sr can be determined in the presence of ^{89}Sr by liquid scintillation counting selected beta energies.

3.10 I.A.E.A. Intercomparison Study of Analytical Methods and Standard Samples. (D. G. Olson)

Simulated air filters have been analyzed for ^{137}Cs , ^{90}Sr , ^{54}Mn , ^{144}Ce , and $^{239, 240}\text{Pu}$ as a part of a laboratory intercomparison study. The program is designed so that standardizations will have been made on the materials which have been analyzed at the conclusion of the study. Thus, laboratories which have had little or no experience in radiochemistry can procure air filters, milk samples, soil samples, etc, to test their capabilities.

3.11 The Fluorometric Determination of Zirconium. (C. W. Sill)

A fluorometric method for the determination of zirconium was developed using 2', 4' dimethoxy-3, 7-dihydroxyflavone. This procedure can detect quantities of zirconium larger than about 0.002 μg and is at least an order of magnitude more sensitive than any other chemical procedure presently known.

3.12 Radiochemical Determination of Uranium and the Transuranium Elements Using Barium Sulfate. (C. W. Sill)

A procedure has been devised whereby virtually every alpha-emitting nuclide known can be precipitated with barium sulfate under the same conditions that permit a true gross alpha determination in large samples. The procedure permits uranium and the first four transuranium elements to be separated from other sample components or from each other. The barium sulfate precipitate can be either alpha-counted directly or the radionuclides can be electro-deposited for high resolution alpha spectrometry. Except for astatine, radon, and francium, recovery of all elements from lead through at least californium is better than 99.99%. At least 1 mg of any element in the Periodic Table can be tolerated without significant interference.

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2. C. W. Sill, G. L. Voelz, D. G. Olson, J. I. Anderson, "Two Studies of Acute Internal Exposure to Man Involving Cerium and Tantalum Radioisotopes", Health Phys. (in press).
3. C. W. Sill, "An Integrating Air Sampler for Determination of Radon", Health Phys. (in press).
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VI. ENVIRONMENTAL BRANCH (C. A. Pelletier)

1. 1968 ENVIRONMENTAL BRANCH ACTIVITIES

1.1 Environmental Monitoring

The concentration of radioactive material in air is monitored continuously at 13 locations (8 on-site, 5 off-site) by drawing air through particulate and charcoal filters. The filters are changed weekly and counted for long-lived alpha and beta radioactivity. In addition, a network of 18 stations (6 on-site, 12 off-site) are operated that measure filterable air radioactivity on a continuous basis. The external gamma radiation levels also are measured continuously at these stations. All stations are interrogated each hour, and these data are telemetered to the Laboratory where they are recorded for subsequent analysis. The telemetry network is designed primarily for emergency situations.

External radiation also is monitored with thermoluminescent dosimeters changed semiannually. Total suspended particulate matter is measured routinely both on- and off-site. A program to measure dustfall on-site was initiated in 1968.

Ground water is monitored to determine the fate of radioactivity released via seepage ponds and disposal wells. All NRTS production wells are sampled weekly. Twelve off-site stations located down the ground water gradient are sampled semiannually. Monitoring wells in the immediate vicinity of disposal facilities are sampled on a variable schedule. The results of these latter samples also are used in research programs.

Composite samples of milk are collected from the Idaho Falls milk shed and are analyzed for ^{131}I and ^{90}Sr .

The wheat crops in southeastern Idaho are sampled at harvest time and are analyzed for ^{90}Sr .

The results of environmental monitoring are reported semiannually. All samples collected in 1968 were found to be below applicable AEC guide values.

1.2 Independent Measurements Program

In late 1967, the Division of Compliance initiated a pilot study in which environmental samples are collected around selected major licensed nuclear

facilities in the United States. A nuclear fuels chemical reprocessing plant, a scrap recover-fuel fabrication plant, and a boiling water power reactor are included in that program to date. The Branch assists in setting up each survey, interprets the data, and reports the results to the Division of Compliance.

1.3 Waste Management

The Branch has staff responsibility to develop guides and regulations for the NRTS concerning environmental disposal wastes. Necessary consultation to site personnel is provided to implement the regulations and guides. Records of waste released to the environment are maintained and reports prepared covering the same. The Branch also provides consultation on problems associated with population radiation exposures from indirect pathways, such as ^{131}I in milk. New criteria for radioactivity in liquid effluents released to the environment at NRTS were developed and approved during 1968.

1.4 Particle Sizing Program

The Branch provides a particle sizing and counting service to contractors. During 1968, samples of boiler stack exhaust were sized and counted for Idaho Nuclear Corporation. Air samples from the Naval Reactor Facility were counted for asbestos particles throughout the year.

1.5 Emergency Response

The Branch is responsible for evaluating hazards to off- and on-site personnel resulting from planned and non-planned releases of radioactivity to the environment. A group of trailers (Trailer City) is maintained in a state of readiness to respond to emergencies at any area on-site. Branch personnel are available to man Trailer City and assist contractor personnel when the need arises. The Branch is responsible for keeping the equipment for the Radiological Assistance Teams in calibration and working order.

1.6 Health Physics

The Branch is responsible for the radiation safety of Laboratory and other ID personnel. Routine contamination surveys are carried out in the Laboratory, Dispensary, and Security Headquarters. Radioactive shipments to the Laboratory are monitored routinely. The face velocities of fume hoods in the Laboratory and Dispensary are measured routinely. No significant problems were noted during 1968.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Controlled Environmental Release Tests (CERT)

The air-forage-milk-human food chain for ^{131}I has been investigated in depth. The objectives of the program are to:

- (1) Define variables which affect the transfer of radionuclides from the point of release to the atmosphere to a human receptor
- (2) Perform controlled experiments to measure the variables influencing observed behavior
- (3) Develop and test predictive models of the processes involved.

During 1968 the following were accomplished:

1. Effect of Stomatal Opening on Deposition. (D. R. Adams)

The capability to control stomatal opening in pasture grasses under laboratory conditions was developed and tested. A technique for measuring the stomatal opening was devised. Analysis of stomatal density (number/unit area) showed marked differences between grass varieties and also along the blade of a given variety. The first of a series of laboratory tests to determine the effect of stomatal opening on deposition was completed.

2. Radioiodine Metabolism Model for Cows. (P. G. Voillequé, R. L. Bangart)

The model is described in IDO-12065. The experimental radioiodine metabolism data from CERT's 20, 23, 24 were used to determine 22 sets of best fit rate constants for the 14 dairy cows used in the tests. Although the results are not conclusive, they support the hypothesis that only about 1/3 as much ^{131}I will be transferred from blood to milk when ingested via contaminated Sudan grass as when ingested via contaminated mixed pasture grass.

3. Efficiencies of Various Filters for Molecular Iodine (I_2). (J. B. Echo)

The results of efficiency measurements for a number of filters are reported in IDO-12065. The measurements described were made with high, total iodine mass loadings. The results have been confirmed by Idaho Nuclear Corporation's Analytical Chemistry Branch. The efficiencies are not the same for low mass loadings.

4. Field Test Grid Preparation and Support. (R. McBride, B. W. Mortensen)

Electrification of the experimental grid for the Experimental Dairy Farm pasture was completed.

5. Environmental Chamber. (C. A. Pelletier)

The design of an environmental chamber was completed, and construction was about 90% complete in 1968 (Figure 7). The chamber has the capability of controlled temperature, humidity, velocity, turbulence, contaminant concentration, and rainfall simulation.

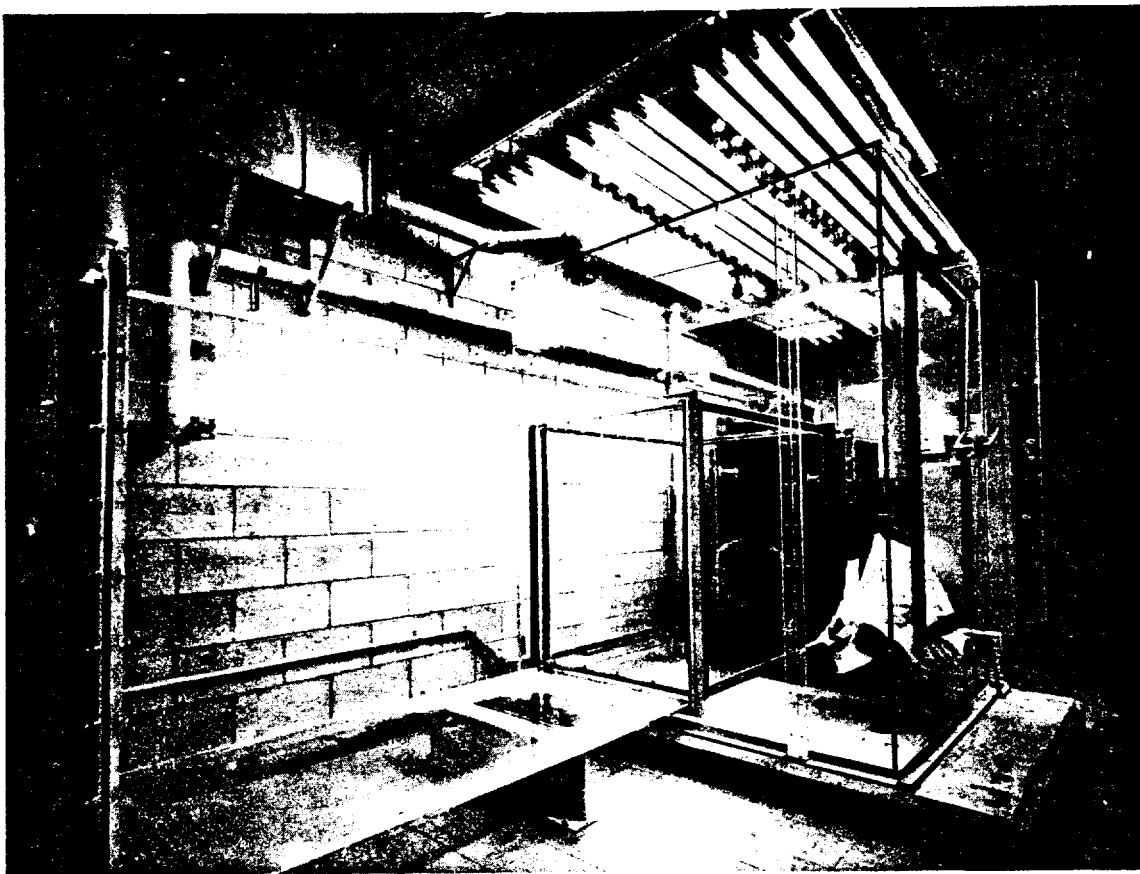


FIG. 7 CONTROLLED ENVIRONMENTAL EXPOSURE CHAMBER.

6. Aerosol Generation and Measurement Technique Development. (R. L. Bangart, B. W. Mortensen)

Tagging methods are being studied. Techniques for separation of particles according to size and methods of release were studied. Calibration and testing of the dust counter were completed.

7. Deposition and Retention. (C. A. Pelletier, J. B. Echo, D. R. Adams)

The deposition velocity of $^{131}\text{I}_2$ (V_D) on Sudan grass ranged from 6.8 to 10.4 cm/sec; values of V_D grass density are in good agreement with the predicted value based on pasture grass relationship. Work continuing on theoretical analyses relating meteorological variables to vertical deposition distribution, ie, vertical distribution as a function of time analyzed with regard to model describing number and density of blades per unit height.

8. $^{35}\text{SO}_2$ Release over Alfalfa. (P. G. Voillequé)

In cooperation with Dr. A. Clyde Hill, University of Utah, a field release of $^{35}\text{SO}_2$ was carried out at the Experimental Dairy Farm. The deposition velocity ranged from 0.4 to 7.5 cm/sec. The values were log-normally distributed with a median of 2.0 cm/sec.

2.2 Experimental Cloud Exposure Study (EXCES)

The objectives of this study, which is just getting underway, are to obtain experimental data from which to develop a mathematical model for cloud gamma dose prediction. Personnel of Idaho Nuclear Corporation and Phillips Petroleum Company also are participating in this program. During 1968, a field test was performed in which ground doses from a release of 32 curies of ^{133}Xe were measured. Based on the results of this test, further study was proposed to and approved by the AEC Division of Reactor Development and Technology.

A safety analysis was performed for the study that shows that it is feasible to release safely up to 1,000 curies of ^{24}Na during a single test.

2.3 Internal Dosimetry. (P. G. Voillequé)

Maximum permissible doses to various organs from plutonium released in the event of a maximum credible accident were derived. A computer model based on the new ICRP lung model was developed (ID-12067).

2.4 Injection of Gas into the Lithosphere. (B. L. Schmalz)

A recently completed research project involved the concept of disposing of gaseous waste in the lithosphere. The test was conducted by injecting one-million cubic feet of air containing 1,000 curies ^{133}Xe into a porous zone 120 feet below the land surface. The movement of this gas was studied by means of

air samples and radiation detection equipment placed in surrounding monitoring wells. Analysis of the results using diffusion equations verified that the movement could be explained on this basis. Variation of estimated flux from that measured was explained on the basis of barometric influences.

It was estimated that of the 1,000 curies injected, 0.5 escaped to the atmosphere during a 24-day period. This amount resulted in concentrations in the atmosphere that were less than the mean concentration of ^{133}Xe in the injected air by a factor of 10^8 .

Mathematical models describing the flow by convective forces created by injection were also tested and found adequate for making engineering estimates in situations where more complete studies are not possible.

2.5 Water Movement in Unsaturated Soil. (B. L. Schmalz, W. L. Polzer)

Interest in leaching of radionuclides and their migration away from buried solid radioactive waste prompted an investigation of water movement in soil under unsaturated conditions. This was accomplished to a depth of 410 cm and compared with that deposited over a 15-year period. On this basis it was concluded that 3.5% remained in the top 200 cm. The observed distribution was comparable with that calculated with an equation based on diffusive and convective processes.

2.6 Movement of Radionuclides in Soil. (W. L. Polzer)

The effects of disposal of liquids containing small amounts of radionuclides are being investigated. The most recent study involves disposal via a pond at the Test Reactor Area. The results confirm previous work showing that the potentially hazardous radionuclides are retained by the soil. For example, approximately 75 curies of ^{137}Cs discharged to the pond during the past 16 years have been sorbed on the soil within the first two feet below the pond bottom. This is congruent with mathematical estimates based on laboratory studies. Cobalt-60 was detected in soil samples 40 feet below the pond bottom; however, it was not detectable in the water extracted from these samples.

2.7 Tritium Studies. (B. L. Schmalz)

Tritium concentration in snow, rain, and stream water is being determined in an effort to monitor NRTS influences and possibly analyze the hydrologic cycle in its environment.

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VII. U.S. GEOLOGICAL SURVEY
(J. T. Barraclough)

1. HYDROLOGIC INVESTIGATIONS AT NRTS

Study of the ground-water hydrologic system at the NRTS was continued during 1968. About 700 measurements of the water level in wells were made to denote changes in water storage; almost 250 ground-water samples were collected to evaluate water quality changes; and over 100 wells were logged with geophysical and radiation probes. Twelve wells were equipped with continuous water level recorders. Three continuous discharge stations were operated on the Big Lost River and 18 stream discharge measurements were made. Technical assistance was provided for tests to evaluate well pumping and injection characteristics.

Mr. R. D. Lamke and Mr. P. L. Soule, USGS, Carson City, Nevada, developed theoretical stage-discharge ratings at nine critical sites on the Big Lost River. The ratings will be used to predict the routing of major floods and to evaluate the effects of flooding on the Big Lost River basin within the NRTS.

A study was made to explain an increase in tritium concentrations from less than 2 $\mu\text{Ci/ml}$ to about 250 $\mu\text{Ci/ml}$ in the water from the Idaho Chemical Processing Plant production wells. Water-level measurements, water samples, and geophysical logs from wells in the area helped to locate the source of contamination.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Analysis of the Underground Radioactive Gas-Injection Tests

The effects of molecular diffusion in the underground radioactive ^{133}Xe gas-injection tests were analyzed by means of a mathematical model and digital computer. Point diffusion rates as high as $3.5 \times 10^{-8} \text{ Ci/hr/ft}^2$ were calculated. The estimates indicate about 0.4 of the 987 curies injected could have diffused from the basalt rocks through the sediments into the atmosphere during the 25 days following the injection.

A materials balance analysis also was completed for this same test. Estimates of the effect of barometric pressure on the ^{133}Xe gas injection test

indicate that this factor could have exceeded the molecular diffusion effects at certain times, but generally had a small effect on the total quantity of ^{133}Xe .

The USGS Equipment and Services Unit, Denver, Colorado, drilled 55 holes at the gas-injection site to determine the thickness of playa deposits and to collect samples. Fifty in-place samples were cored, 22 of which were sent to the USGS Laboratory at Denver for various analyses. Natural gamma-radiation logs were obtained to give the characteristics of the sediments. The logs show variations in sediment properties that may relate to the air permeability.

The USGS Hydrologic Laboratory ran five vertical air permeability tests on cores from the playa deposits at the gas-injection site. The air permeability ranged from 0.1 to 1.8 darcys and averaged 1.3 darcys. These values are considerably lower than permeabilities obtained in the air-injection test suggesting that soil cracks may add to the permeability.

2.2 Seismic Investigations at the NRTS, Idaho

An investigation was made on the transmission of seismic effects as a result of a proposal to fire large caliber naval guns at the NRTS. Calculations based on previous seismic data indicate that the resultant seismic acceleration would be less than 1% of that required to scram the nearest reactor, which is about two miles from the firing site. The seismic effect would be considerably lessened at more distant reactors.

A study was begun by H. E. Malde, USGS, Denver, Colorado, to determine the potential for faulting and earthquakes at or near the NRTS. Preliminary study was made of certain lineaments and faults of the area. As part of the investigation, six telemeter seismograph stations were installed by the staff of the USGS National Center for Earthquake Research. Data from these stations are automatically transmitted to Menlo Park, California.

The effects of three Nevada Test Site underground nuclear tests on the water level in the Materials Testing Reactor test well were observed. The tests on January 19, April 26, and December 19, 1968, caused maximum fluctuations of 0.20, 0.28, and 0.18 feet, respectively. The fluctuations of the water-level recorder pen were photographed during the last test with 100 feet of 16-mm black-and-white movie film. Transmission time required nearly four minutes, and the period of oscillations was about five seconds.

2.3 Investigations of the Effects of Underground Waste Disposal

In support of the AEC's study of radioactive waste disposal by ponds at the Test Reactor Area (TRA), 28 wells were augered 30 to 60 feet deep in the Big Lost River alluvium (Figure 8). Thirty-two in-place drive core samples were taken. Four holes were drilled utilizing angle-drilling techniques in order to penetrate beneath the edges of the ponds at various angles. Radioactivity was found from 10 to 20 feet deep at low-moisture areas near the older pond and at deeper locations in high-moisture zones near the newer pond.

About 3,000 feet of gamma-ray, neutron-epithermal neutron, and gamma-spectral logs were run in the auger holes. W. S. Keys and L. M. McGary, USGS research hydrologists from Denver, Colorado, identified ^{60}Co by spectral logging in many of the holes. This is one of the first successful uses of spectral logging. Neutron logs in the new TRA holes show that the moisture from record high August rains had penetrated less than five feet of alluvium.

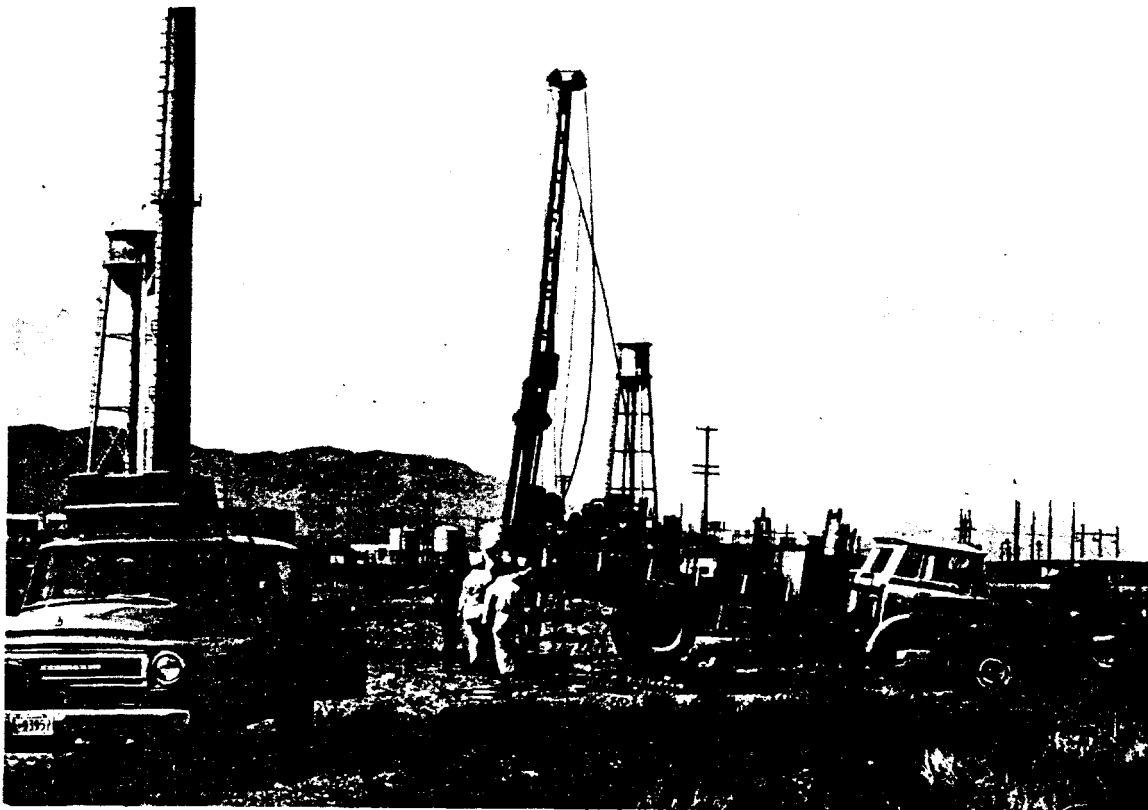


FIG. 8 VIEW OF ANGLE DRILLING NEAR A RADIOACTIVE WASTE POND. THE DRILLING ENABLED ALLUVIAL AND WATER SAMPLES TO BE COLLECTED BENEATH THE POND AND RADIATION LOGS TO BE RUN.

VIII. AIR RESOURCES LABORATORIES FIELD RESEARCH OFFICE,
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

U.S. Department of Commerce
(C. R. Dickson)

1. OPERATIONAL METEOROLOGICAL SERVICES

A technique was developed for the operational use of tetroons to approximate the plume position in event of an accidental effluent release. Tetroons are weighed and placed in automatic release devices at plant locations. Analysis of heights of density surfaces, the variance of these heights, and analysis of the variance in the vertical density gradient were made in order to be able to predict the mean height of a tetroon possessing a precalculated free lift at the surface. Experiments were conducted to test the predictions with observations.

The prediction of maximum daytime winds using the Regression Estimates of Event Probabilities (REEP) technique was completed for the mid-spring (April to May) season. Preliminary results and comparisons with subjective forecasts have been completed for both the spring and winter seasons.

A prediction scheme has been developed for winds at a single point with time as a dependent variable.

Subjective forecasts were verified for 1965 to 1968. The errors were analyzed for use in comparing objective forecasts.

Meteorological forecasts were given for special reactor operations and tests.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Radar-Tetroon-Transponder System

Digitized tracking data from two radars, simultaneously tracking tetroons, were used to determine the accuracy of the M-33 radars and examine some Lagrangian dispersion characteristics.

2.2 Mesoscale Turbulence and Diffusion Studies

The feasibility of realistically depicting mesoscale flow patterns through objective analysis of wind data from a network of randomly spaced wind stations was investigated. Characteristics of the flow patterns, such as divergence and vorticity, were used in the investigations. The data from the mesogrid stations are stored on magnetic tape. The analysis and display of the wind fields and trajectories, constructed with the data, have been completely automated. Experiments, including pilot balloons, surface temperatures, temperature soundings, and tethered flights, were conducted in conjunction with the data from the mesonet wind stations in order to study the mechanisms governing the mesoscale flow. Hypothetical trajectories were constructed for the purpose of comparison with the tethered trajectories. The computer program that computes the trajectories has been modified to take into account the upper level winds. The validity of the random-to-grid interpolation schemes has been tested on some hypothetical flow patterns.

2.3 Time Series Analysis of Turbulence Data

The formidable and expensive task of computing correlation functions and power spectra from long periods of data has been drastically simplified and reduced in cost by implementing the Fast Fourier Transform (FFT) into the analysis scheme. Spectral analysis on long periods of bivane data has been carried out. Comparisons have been made between bivane, cup anemometer data, and hot-wire anemometer data using the FFT.

2.4 Hemispheric Dispersion Study

Numerical Meteorological Center's 500 mb stream function data have been used to examine the north-south isobaric dispersion of material released on a latitude circle. Work has begun on the computation of the dispersion of the material by the long-wave disturbances, obtained by combining the first few harmonics of the decomposed flow fields.

2.5 Deposition and Depletion Studies

Meteorological support was given for field releases of $^{131}\text{I}_2$ over Sudan grass and $^{35}\text{SO}_2$ over alfalfa. This office participated in the planning, installation of instrumentation, data gathering, and data analysis for these releases.

The absolute deposition of uranine dye was calculated after the first 400 meters of atmospheric transport through comparisons to methyl iodide concentration measurements. The same deposition calculations were made for a simultaneous, dual-tracer release of molecular iodine and methyl iodide. The deposition of uranin dye relative to molecular iodine has been estimated from a pair of dual tracer releases.

Contrary to earlier beliefs, only a relatively small percentage of molecular iodine on particle prefilters has been found to result from an unsuspected high collection efficiency at very low levels of iodine loading in the filter.

2.6 Field Diffusion Measurements Over Extended Periods and Downwind Distances

The goals and reasearch approach to diffusion over extended periods were carefully reviewed. Some potentially important, previously omitted meteorological factors or mathematical formulations in dispersion calculations were recognized. A preliminary study of these factors is in progress to evaluate them and remove their influence from the measurements of diffusion over extended periods.

2.7 Diffusion Research Model for LOFT Support Studies

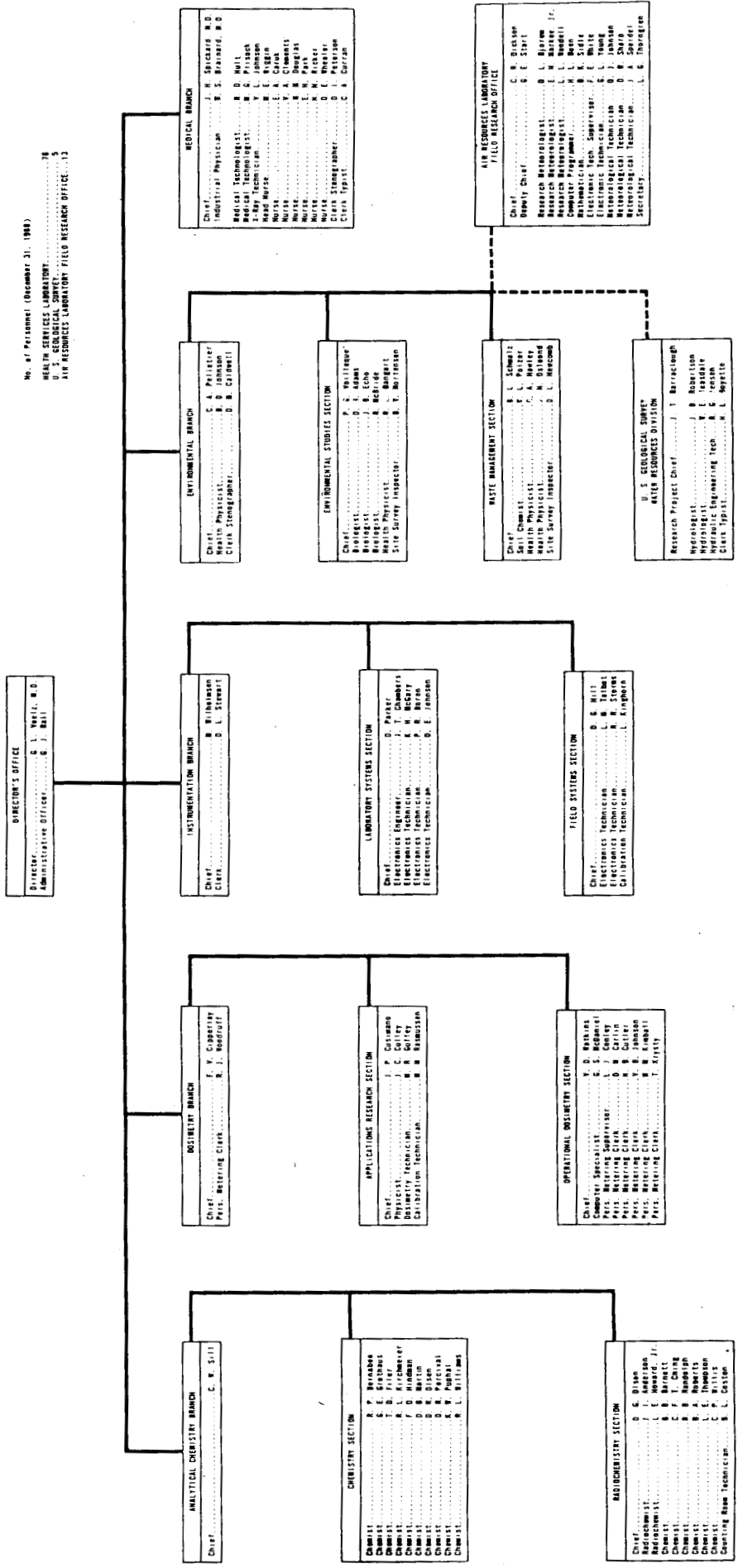
The diffusion research model developed previously has been modified. The earlier model used wind data from a single point to estimate the speed and direction of effluent transport. The latest version of the model incorporates transporting winds extracted from a wind field based on a number of surrounding, randomly spaced wind reporting stations. The dispersion patterns resulting from the use of a transporting field and the resulting calculated values of relative dose factors look very good.

3. PUBLICATIONS

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2. S. K. Kao and L. L. Wendell, "Some Characteristics of Relative Particle Dispersion in the Atmosphere's Boundary Layer", Atmospheric Environ., 2 n 4 (July 1968) pp 397-407.

3. C. R. Dickson and J. K. Angell, "Eddy Velocities in the Planetary Boundary Layer as Obtained from Tetroon Flights at Idaho Falls", J. of Appl. Meteorology, 7 n 6 (December 1968) pp 986-993.
4. C. R. Dickson, G. E. Start, E. H. Markee, Jr., "Aerodynamic Effects of the EBR-II Reactor Complex Effluent Concentrations", Nuclear Safety, 10 (in press).

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