41 19758

IDO-12073

IDO-12073
July 1970

1969 ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

A. T. Morphew 9/26/73

NATIONAL REACTOR TESTING STATION

IDAHO OPERATIONS OFFICE
U. S. ATOMIC ENERGY COMMISSION

1131952

Printed in the United States of America
Available from
Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U. S. Department of Commerce
Springfield, Virginia 22151
Price: Printed Copy $3.00; Microfiche $0.65

IDO-12073
Health and Safety
TID-4500
Issued: July 1970

1969
ANNUAL REPORT
OF THE
HEALTH SERVICES LABORATORY

George L. Voelz, M.D.
Director

UNITED STATES ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
P.O. BOX 2108
IDAHO FALLS, IDAHO
83401

PREFACE

It is with considerable pride that the staff of the Health Services Laboratory, Idaho Operations Office has prepared this annual report. 1969 has been a busy year and in this report we have tried to briefly outline the contributions that the Laboratory has made to radiological science, occupational health, and environmental studies during the year. Although these descriptions do not contain enough detail to evaluate the work, we hope that it shows the general scope of our work and investigations. We invite you to direct inquiries to us for additional details and to exchange viewpoints on particular projects that may be of interest to you.

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

April 1970

CONTENTS

PREFACE ii

I. INTRODUCTION 1

II. A DECADE OF PERSONNEL RADIATION EXPOSURE EXPERIENCE 3

1. INTERNAL RADIATION EXPOSURES 4
2. CHANGES IN PERSONNEL MONITORING TECHNIQUES 5
3. REFERENCES 11

III. DOSIMETRY BRANCH 12

1. OPERATIONAL DOSIMETRY ACTIVITIES 12

1.1 Summary of External Radiation Exposure Statistics 12
1.2 Summary of Internal Radiation Exposure Statistics 12
1.3 Off-Site Coverage 12

2. SPECIAL PROBLEM DOSIMETRY 13

2.1 Measurement of Gamma Dose Levels at SPERT IV 13
2.2 Neutron Flux Measurement 13
2.3 Measurement of Phoenix Fuel Rods 13
2.4 Shielding Design Tests 13
2.5 Independent Measurements Program 13

3. RESEARCH AND DEVELOPMENT PROJECTS IN DOSIMETRY 14

3.1 Radiation Effects 14
3.2 Neutron TLD Investigation 14
3.3 CaF_2:Mn Study 14
3.4 Automatic Thermoluminescence Analyzer System (ATLAS) 16
3.5 X-Ray Facility Development 16
3.6 Electronic Data Processing 16

IV. MEDICAL BRANCH 18

1. ROUTINE MEDICAL ACTIVITIES 18

2. SUMMARY OF 1968 MEDICAL BRANCH WORK STATISTICS . . . 19

2.1 NRTS Work Population Change 19
2.2 Patient Visits to AEC Dispensaries 19
2.3 Patient Visits to All NRTS Dispensaries and First-Aid Stations 20
2.4 Physical Examination Programs 20
2.5 Laboratory and X-Ray 20

3. REVIEW OF SPECIAL PROJECTS 21

3.1 Blood Chemistry Profiles 21
3.2 Whole-Body Counting 23

3.3 Pulmonary Function Testing 23
3.4 Pre-Employment Medical Questionnaire 24

4. PUBLICATION 24

V. INSTRUMENTATION BRANCH 25

1. ROUTINE INSTRUMENTATION ACTIVITIES 25

1.1 Field Instrumentation Maintenance 25
1.2 Laboratory Instrumentation Maintenance 25

2. SPECIAL INSTRUMENTATION SUPPORT ACTIVITIES 25

2.1 Manually Operated Alpha Counters 25
2.2 Dark-Room Water-Bath Heating and Temperature Control 25
2.3 Assistance for S5G 26

3. INSTRUMENTATION RESEARCH AND DEVELOPMENT PROJECTS 26

3.1 Aerial Monitoring System 26
3.2 In Vivo ^{239}Pu Detection 26
3.3 Automatic Changer for Alpha Samples 26
3.4 High Speed Telemetry System 26

4. PUBLICATION 26

VI. ANALYTICAL CHEMISTRY BRANCH 28

1. 1969 ANALYTICAL CHEMISTRY BRANCH ACTIVITIES 28

1.1 Routine Analytical Chemistry Activities 28
1.2 Independent Measurements Program 28

2. RESEARCH AND DEVELOPMENT PROJECTS 28

2.1 Whole-Body Counting 28
2.2 Analysis of Luminescent Source in Liquid Scintillation Counting 30
2.3 Recoil Studies 30
2.4 Gamma Detector Systems 30
2.5 Carbon-14 in Environmental Samples by Liquid Scintillation 30
2.6 Determination of All Alpha Emitters on Barium Sulfate 31
2.7 High Resolution Alpha Spectrometry on Cerium Hydroxide 31
2.8 Radiochemical Determination of Alpha Emitters from Large Samples of Bone Ash 31
2.9 Determination of Enriched Uranium and Plutonium in Biological and Environmental Samples 31
2.10 Gross Alpha Research 31
2.11 Electrodeposition Procedure for High Resolution Alpha Spectroscopy 32

2.12 Sequential Radiochemical Determination of ^{226}Ra, ^{228}Ra, ^{227}Ac, and ^{230}Th in Environmental Waters, Air Dusts, Ores, and Uranium Mill Process Wastes 32
2.13 Simplified Direct De-Emanation Method for the Determination of ^{226}Ra 32
2.14 Studies on the Adsorption and Desorption of ^{222}Rn on Activated Charcoal 32
2.15 Retention of ^{222}Rn in Mylar and Saran Bags 33
2.16 Internal Dosimetry 33
2.17 Factors Affecting Alpha Particle Counting Efficiency 33
2.18 Special ^{222}Rn Analyses 33
2.19 Determination of ^{125}I and ^{131}I in Bovine Thyroids 33
2.20 Separation of ^{225}Ac from a Mixture of ^{229}Th, ^{228}Th, and Daughters 34
2.21 Purification of Cerium Carrier 34
2.22 Separation of ^{228}Ra and ^{228}Ac Tracers from Old Thorium Salts 34
2.23 Determination of ^{90}Sr 34
2.24 Radiochemical Analysis of Large Samples of Oysters 34
2.25 Spontaneous Deposition of ^{210}Po on Silver Discs 35
2.26 The Fluorometric Determination of Thorium 35
2.27 The Fluorometric Determination of Zirconium 35
2.28 The Fluorometric Determination of Germanium 36
2.29 Radiochemical Determination of ^{231}Pa and ^{210}Po in Environmental and Biological Materials 36

3. PUBLICATIONS 36

VII. ENVIRONMENTAL BRANCH 37

1. ROUTINE ACTIVITIES 37

1.1 Environmental Monitoring 37
1.2 Independent Measurements Program 37
1.3 Waste Management 38
1.4 Particle Sizing and Counting 38
1.5 Emergency Response and Preparedness 38
1.6 Health Physics 38

2. RESEARCH AND DEVELOPMENT PROJECTS 39

2.1 Controlled Environmental Release Test (CERT) Program 39
2.2 Injection of ^{133}Xe into the Lithosphere 40
2.3 Movement of Radionuclides in Soil 40
2.4 Tritium Studies 40
2.5 Sampler Development 40
2.6 Comparative Deposition Test 41

2.7 Internal Dosimetry 41
2.8 Experimental Cloud Exposure Study (EXCES) 42

3. PUBLICATIONS AND PRESENTATIONS 42

VIII. U.S. GEOLOGICAL SURVEY 43

1. HYDROLOGIC INVESTIGATIONS AT NRTS 43

2. RESEARCH AND DEVELOPMENT PROJECTS 43

2.1 Investigations of the Effects of Underground Waste Disposal 43
2.2 Catastrophic Floods at NRTS 44
2.3 Seismic Investigations at NRTS 44

3. PUBLICATIONS 45

IX. AIR RESOURCES LABORATORIES FIELD RESEARCH OFFICE, ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION 46

1. RESEARCH AND DEVELOPMENT PROJECTS 46

1.1 Measurement Program Over Los Angeles Basin 46
1.2 Mesoscale Turbulence and Diffusion Studies 46
1.3 Study of Cloud Removal Processes 47
1.4 Forecast Verification 47
1.5 Wind Studies 47
1.6 Turbulence Analysis 48
1.7 Sampling Time Effects on Measurements of Surface Boundary Layer Turbulence 48
1.8 Mesoscale Diffusion 49

2. PUBLICATION 49

APPENDIX -- ORGANIZATIONAL CHART OF THE HEALTH SERVICES LABORATORY 51

FIGURES

1. Automatic film reader 6
2. Semi-automatic thermoluminescent dosimeter reader 7
3. Automatic badge calibrator 8
4. Medical van contains equipment for taking whole-body counts, chest X-rays, and clinical laboratory samples 10
5. ID thermoluminescent badge for environmental low level measurements 15
6. Film reader with data processor unit and tape transport system 17
7. Central Facilities and AEC Headquarters dispensary visits 20

8. Physical examinations performed at NRTS 22
9. X-ray, laboratory procedures, and routine whole-body counts 22
10. Automatic sample changer for alpha spectrometry 27
11. Isometric plot of whole-body counter 29
12. Laboratory apparatus for soil ion exchange studies 41
13. Fault in excavation north of Arco, Idaho 45

TABLES

I. Persons Exposed to External Radiation at NRTS 4
II. Ten Highest Accumulated NRTS Exposures 5
III. 1969 NRTS Dispensary Visits 21
IV. Abnormal Chemistry Tests in 884 Examinations 23

1969 ANNUAL REPORT OF THE HEALTH SERVICES LABORATORY

I. INTRODUCTION

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

There were no major organizational changes during 1969. As of December 1969, the staff totaled 76 persons, which is the same number of employees that was employed a year ago. However, the total number of professional staff members was reduced from 51 to 49 persons during the year. The number of technicians on the staff remained at 19. The clerical and administrative staff was increased by 2 persons. In addition, the U. S. Geological Survey and the ESSA groups employ 4 and 12 people respectively, which is one less employee than each group had a year ago.

The Laboratory organization is such that all persons performing research and development work also have responsibilities for operational programs in their specialty. This tends to tie the research programs 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. Work on thermoluminescent dosimetry and analytical chemistry procedures were particularly noteworthy in this regard during the past year.

The primary task of the Laboratory is to support 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 receives about 11% of its support from the AEC Division of Biology and Medicine for specific research and development work. Thirteen percent of Laboratory effort is devoted to the Independent Measurements Program for the AEC Division of Compliance to aid in their evaluation of environmental measurements which are made at various licensee plants in other locations throughout the United States. This is a slightly increased effort compared to a year ago.

The operational activities of the Laboratory are covered only superficially 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.

The following section of this report describes the results and developments in personnel dosimetry at the NRTS during the past decade. The techniques and

instrumentation have changed notably during the period 1960-1969 so it seemed that information on our experience in these areas would be of interest to others.

II. A DECADE OF PERSONNEL RADIATION EXPOSURE EXPERIENCE

The National Reactor Testing Station (NRTS) was established in 1949 as a place where the U. S. Atomic Energy Commission could build, test, and operate various types of nuclear reactors and allied plants and equipment with maximum safety. Today, the NRTS is one of the Commission's principal centers for developing peacetime uses of atomic energy. It has the world's largest and most varied collection of reactors, including research, testing, power, and propulsion reactors.

The NRTS mission is to develop economic and safe nuclear power furthering the Commission's reactor development program. To that end, more than 45 reactor facilities have been placed in operation or are under construction or design. Programs at the NRTS include test irradiation services, transient reactor safety experiments, chemical processing of highly enriched fuels and associated developments, and breeder reactor and naval propulsion reactor development, as well as various technical and common support services.

The history of plant operations has proved that NRTS personnel are not subjected to a higher degree of occupational hazard than are personnel at installations or industries where operations are more routine. This experience results from careful attention to personnel protection procedures and practices under the surveillance of well-trained health and safety personnel.

It seems particularly fitting in the 1969 annual report of the Health Services Laboratory to present a brief summary of the radiation exposure experience at NRTS during the past decade. The monitoring of personnel for internal and external radiation exposures at the NRTS is a cooperative effort of the Analytical Chemistry Branch and the Dosimetry Branch.

In one sense, a simple presentation of the exposure data becomes a tribute to the hundreds of persons who have contributed to this achievment of a safe working environment in a unique industry. The record is by no means perfect. The most serious reactor accident in the United States to date, the SL-1 accident, occurred at the NRTS in 1961. Despite this and other minor accidents, the favorable experience on radiation exposure control is impressive.

During the ten year period of 1960 through 1969, personnel monitoring coverage has been provided to an average of 7,900 persons per year. This has involved the processing and evaluation of 1,386,897 dosimetry badges and the performance of 88,930 urinalyses and 14,338 in vivo determinations on humans. During this time a total occupational whole body external radiation exposure of 23,581 rem has been accumulated at an average rate of 0.314 rem per person per year. Table I shows the number of individuals who received external whole body exposures by selected annual exposure levels from 1960 through 1969.

Although direct external radiation is the principal source of personnel exposure at the NRTS, the data show that 85% of those monitored accumulated less than 500 mrem in an average year, 97.5% accumulated less than 3.0 rem per year, and 99.8% accumulated less than 5 rem per year. Although 129 persons did exceed a total radiation dose of 5 rem for a given year, none exceeded the AEC radiation protection standard of 5(n-18) rem average for total occupational accumulated dose.

TABLE I

PERSONS EXPOSED TO EXTERNAL RADIATION AT NRTS

1960-1969

Year	Total Persons	rem/year 0 - 0.5	0.5 - 3.0	3.0 - 5.0	≥5.0
1960	7,727	6,479	1,112	135	1
1961	7,237	5,875	1,112	222	28[a]
1962	8,423	7,438	819	138	28
1963	8,238	7,076	1,024	138	0
1964	8,248	7,030	1,051	167	0
1965	7,896	6,383	1,114	333	66[b]
1966	7,155	6,189	774	187	5
1967	8,233	7,166	896	171	0
1968	8,086	7,072	883	130	1
1969	7,758	6,792	863	103	0

[a] These exposures resulted from the SL-1 incident. Three persons were killed by blast effect in the accident and received high radiation exposure but are not listed in this total.

[b] These were planned exposures necessitated by special tests performed by three contractors.

The highest individual accumulated radiation exposures, which are tabulated in Table II, show the highest exposure total accrued by any one individual was a total of 57 rem over a 17-year work period. The list of highest accumulated exposure totals shows that only two females received in excess of 5 rem total during their work period at the NRTS. The occupational crafts receiving the highest exposures were mechanics, reactor technicians, and pipe fitters.

During this ten year period there were no localized external exposures in excess of the annual AEC radiation protection standards. However, one individual did receive an exposure of 31 rem to his hand, which exceeded the quarterly exposure standard.

1. INTERNAL RADIATION EXPOSURES

There has been a remarkably low incidence of significant internal deposition of radionuclides resulting from NRTS operations. During the years 1960 through 1969, there were no internal radionuclide exposures that resulted in a radiation dose in excess of the annual radiation exposure standard. In fact, there has been only one such event at the NRTS. In 1958, an accidental

TABLE II

TEN HIGHEST ACCUMULATED NRTS EXPOSURES

Male Workers			Female Workers		
Occupation	Service (yrs)	Exposure (rem)	Occupation	Service (yrs)	Exposure (rem)
Mechanic	17	57.4	Technician	16	28.6
Mechanic	17	52.3	Chemist	9	13.3
Engineer	14	49.2	Analyst	9	4.5
Fitter	16	48.3	Secretary	11	2.7
Technician	13	47.4	Secretary	9	2.4
Technician	14	47.2	Technician	14	1.9
Fitter	14	45.5	Technician	18	1.4
Fitter	17	44.0	Clerk	14	1.4
Technician	17	43.9	Technician	5	1.1
Fitter	16	41.8	Chemist	17	1.0

airborne release of radioactive gases, primarily ^{131}I, resulted in six individuals receiving thyroid doses of 220, 210, 86, 48, 32, and 31 rad. Four others received exposures of less than 30 rad to the thyroid at the same time.

Two other inhalation exposures [11] that occurred in 1967 are of interest. In one incident elimination of ^{141}Ce, ^{144}Ce, and ^{95}Zr-Nb through the gastrointestinal tract resulted in a total dose of 10 rem to the lower large intestine of one individual. In the other incident, a lung dose of 13 rem resulted from the inhalation of ^{182}Ta and ^{183}Ta.

2. CHANGES IN PERSONNEL MONITORING TECHNIQUES

During the ten year period, numerous improvements in procedures, systems, and instrumentation were implemented. For personnel monitoring of external radiation, an automatic film reader[1] (see Figure 1) capable of reading some 600 films per hour was designed and fabricated as well as a semi-automatic reader for reading nonroutine film[2]. Computer programs[3] were prepared for automatic data reduction and evaluation, and for report preparation. A thermoluminescence dosimetry system[4] having a six-month servicing schedule was initiated, a semi-automatic thermoluminescent dosimeter reader[5] (see Figure 2) was designed and fabricated enabling computer evaluation of the dosimeter results, and an automatic badge calibrator (see Figure 3) was constructed,

Fig. 1 Automatic film reader.

enabling the precise timing of exposures. A personnel neutron threshold detector capable of measuring neutron flux at five energy levels was designed, a new system of distribution and servicing of dosimetry badges was instituted, and new devices and procedures were devised for environmental monitoring and special applications [6].

One result of these improvements was the reduction in Dosimetry Branch personnel from 33 in 1960 to 14 in 1969. During this time, the number of persons provided with personnel monitoring coverage per operational dosimetry employee increased from approximately 300 in 1960 to more than 900 in 1969.

Whole-body counting was started at the NRTS in January 1961. The convenience, sensitivity, and reliability of whole-body counting made it the choice of personnel monitors for internal radioactivity from gamma-emitting nuclides. Preliminary calibrations had been made in time to count 24 individuals involved in the SL-1 incident. Since that time over 14,000 in vivo determinations have been made and radioactivity of 48 different nuclides has been detected in individuals receiving occupational or environmental exposures. Over 97% of the exposures involved less than 0.1 μCi with less than 0.4% being in the range of 1 to 10 μCi. In most cases, where a significant amount of activity has been detected, the mode of excretion from the body, the effective half-life, and the nuclides

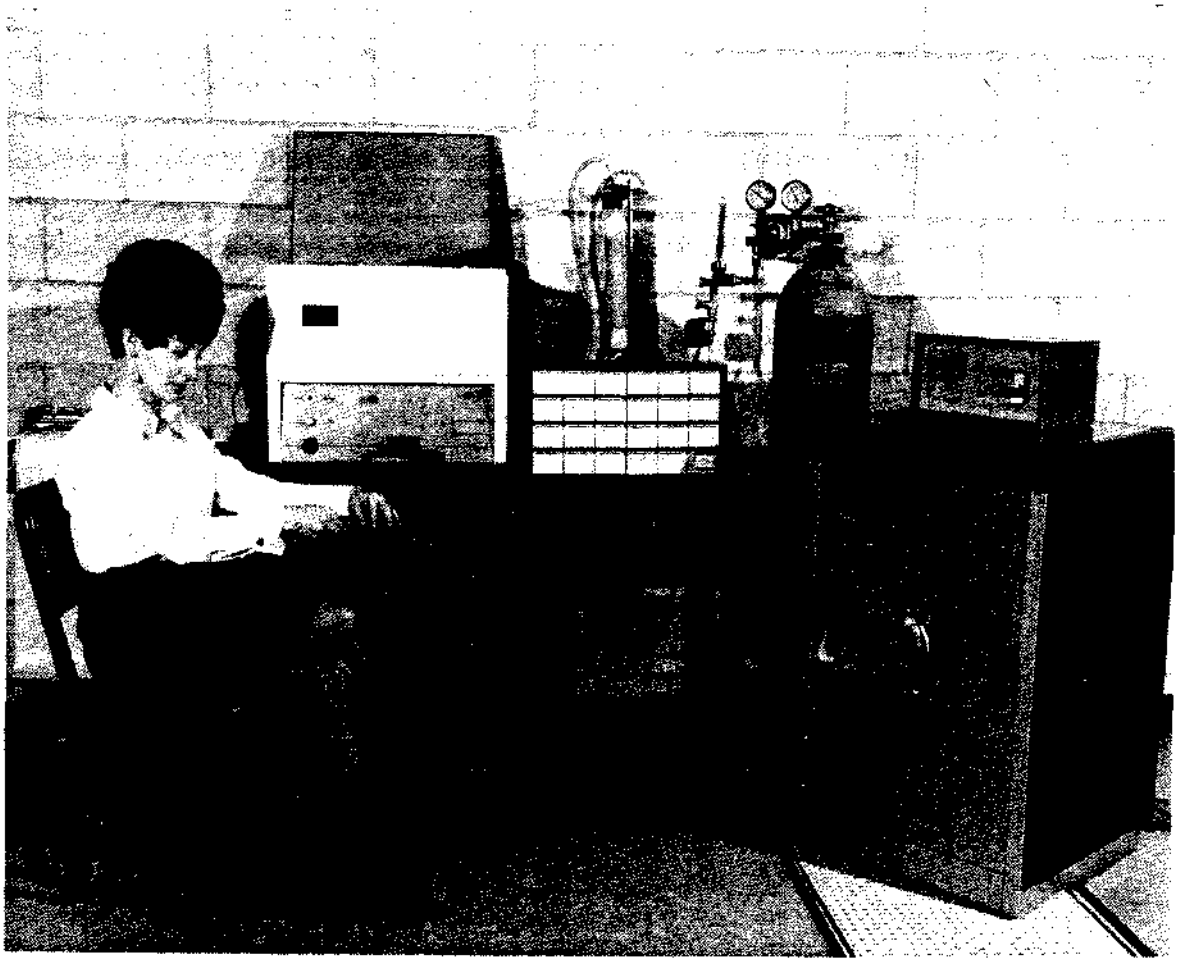


Fig. 2 Semi-automatic thermoluminescent dosimeter reader.

involved have been determined. The procedures for counting have changed from that of requiring a complete shower and use of a special paper counting gown to that of counting in street clothes and not requiring a shower. A shower and paper gown are only used when a significant amount of activity is detected.

Before the advent of the whole-body counter, approximately 12,000 urinalyses were made each year as a monitor of activity inadvertently received by site personnel. Whole-body counting has shown that the major nuclides received by individuals involved in incidents at the NRTS are eliminated from the body through the GI tract, and only a few specific nuclides are found in urine. Consequently, urinalyses as a routine monitoring technique has been abandoned by this laboratory. Urine is analyzed only for iodine, uranium, and strontium or for elimination studies on specific isotopes.

A portable, unshielded whole-body counter[7] was developed and constructed in 1963. This counter was used to monitor people involved in an incident which occurred when a shipment of methyl iodide released activity in an airplane. Twenty-two people were counted at the Salt Lake City airport with 14 showing positive results. Six individuals were counted at the Idaho Falls airport with two showing positive results.

A medical van[8] (see Figure 4), which contains a whole-body counter, was designed and purchased in 1965. The van made it possible to count more people in less time at the individual plant areas. Consequently, the number of individuals counted in the laboratory has decreased from 2,400 in 1966 to 480 in 1969. Personnel having significant activity when counted in the van are sent to the laboratory for confirmation of activity, dose determination, and follow-up studies.

Whole-body counting equipment available at the Analytical Chemistry Branch Laboratory now includes rotational counting[9], helical scanning[10], and a detector for determining the strontium-90 in the skeleton[11] by counting the Bremsstrahlung emission from the skull.

All of the information gathered from the various personnel monitoring devices must be made a matter of record, which can be readily produced if necessary. In this respect we have a dual responsibility: to protect the worker from harmful accumulated radiation exposure and to provide dosimetry information to the Commission and NRTS Contractors on personnel exposures resulting from employment at the NRTS. The Idaho Nuclear Computer Sciences Center is utilized to compute and compile the dosimetry evaluation and to maintain the record keeping system from which all reports and retrieval of information are derived.

Fig. 4 Medical van contains equipment for taking whole-body counts, chest X-rays, and clinical laboratory samples.

3. REFERENCES

1. R. B. Purcell and K. H. McGary, Automatic Film Density Reading System, IDO-12029 (April 1963).

2. K. H. McGary and P. R. Boren, Dosimetry-Film Densitometer with Automatic Card-Punch Control, IDO-12062 (July 1967).

3. F. V. Cipperley, "Application of Computers to Radiation Protection Problems", Health Physics, 12 (February 1966) pp 1601-1608.

4. J. P. Cusimano and F. V. Cipperley, "Personnel Dosimetry Using Thermoluminescent Dosimeters", Health Physics, 14 (April 1968) pp 339-344.

5. J. P. Cusimano, F. V. Cipperley, and J. C. Culley, Special Applications of Thermoluminescence Dosimetry, IDO-12068 (June 1968).

6. D. Parker and J. I. Anderson, "A Portable Whole-Body Counter", Health Physics, 12 (February 1967) pp 141-148.

7. L. E. Howard, Jr., J. H. Spickard, and M. Wilhelmsen, A Human Radioactivity Counter and Medical Van, (in preparation).

8. J. I. Anderson and D. G. Olson, "A Rotational Technique for Assessing Quantity and Distribution of Body Radioactivity", Health Physics, 13 (July 1967) pp 719-732.

9. J. I. Anderson, D. Parker, and D. G. Olson, "A Whole-Body Counter with Rotating Detectors", Health Physics, 16 (June 1969) pp 709-717.

10. D. G. Olson, "In Vivo Determination of ^{90}Sr by Analyzing Bremsstrahlung from the Skull", to be published in the Proceedings of the Symposium on Health Physics Operational Monitoring, Los Angeles, California, January 29-31, 1969.

11. C. W. Sill, G. L. Voelz, D. G. Olson, and J. I. Anderson, "Two Studies of Acute Internal Exposure to Man Involving Cerium and Tantalum Radioisotopes", Health Physics, 16 (March 1969) pp 325-332.

III. DOSIMETRY BRANCH

(F. V. Cipperley)

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

1. OPERATIONAL DOSIMETRY ACTIVITIES

1.1 Summary of External Radiation Exposure Statistics

In 1969 services were provided for 25 contractors at 21 separate geographical locations at the NRTS. More than 7,000 persons were monitored during the year which involved the processing of approximately 54,254 permanently assigned beta-gamma dosimeters. The Branch also provided special processing of 1,896 permanently assigned dosimeters at the request of the contractors' health physicists, and processed some 65,552 other nonroutine items. In addition nearly 26,000 temporary dosimeters for transient personnel were processed during the year, and personnel monitoring coverage was provided for approximately 200 personnel of three off-site governmental agencies involving some 600 TLD badges. A total of 119,806 dosimeters of various types were processed during the year.

The exposure data show that 6,792 persons, or 87.5%, accumulated less than 500 mrem (the level at which monitoring is required), 863 persons or 11.2% accumulated between 0.5 and 3.0 rem (the AEC radiation protection guide for a calendar quarter), and 103 persons, or 1.3%, accumulated between 3.0 and 5.0 rem. No one exceeded 5.0 rem (the radiation protection guide per year for occupational exposures).

The total accumulated whole-body exposure for the entire NRTS for 1969 was 1,723 rem for an average of 259 mrem per person covered by the program, compared to the current ten-year average of 314 mrem per year.

1.2 Summary of Internal Radiation Exposure Statistics

Results of 7,053 urinalyses and 1,641 in vivo determinations performed by the Analytical Chemistry Branch and the Medical Branch during 1969 were entered into the personnel radiation exposure records by the Dosimetry Branch. No significant exposures were found.

1.3 Off-Site Coverage

The Dosimetry Branch has provided thermoluminescence dosimetry (TLD) coverage for approximately 150 low-exposure-risk people working at the Nuclear Rocket Development Station (NRDS) in Nevada beginning in January 1969. During the year, additional TLD coverage was requested for nearly all the people at the NRDS. At the end of 1969, coverage was being provided for

approximately 500 people and discussions were underway regarding the provision of complete recordkeeping services.

TLD coverage is also furnished for perosnnel of the Compliance Division, Region IV, at Denver, Colorado and for members of the Radiological Assistance Team at the AEC Headquarters.

2. SPECIAL PROBLEM DOSIMETRY

2.1 Measurement of Gamma Dose Levels at SPERT IV

Personnel of the Dosimetry Branch assisted the Idaho Nuclear Corporation's Instrumentation and Control Branch in determining the feasibility of using holography techniques for reactor measurements. Gamma radiation levels were measured at various locations around the SPERT IV reactor during excursion. Measurements were taken at four locations ranging from 1 foot to 18 feet above the top of the reactor core. Exposures ranged from 370 R at 1 foot above the core, to 18 R at 18 feet above the core. Further tests will be performed to determine the radiation damage, if any, to holography film at these levels.

2.2 Neutron Flux Measurement

An unusual contractor service was performed for the Argonne National Laboratory at the Zero Power Reactor Three (ZPR-III). During a five-kilowatt, five-day power run at ZPR-III, an ordinary personnel neutron threshold detector (PNTD), a standard item in the NRTS dosimetry badge, was utilized to measure neutron doses in excess of one billion rad. This feat is noteworthy in that the PNTD was designed for use at personnel exposure dose levels and for much shorter time intervals.

2.3 Measurement of Phoenix Fuel Rods

Techniques were developed using TLD-700 and TLD-600 to determine the thermal neutron component in mixed radiation measurements. The technology developed was applied in performing measurements on the Phoenix fuel rods prior to use in the MTR. This allowed handling techniques to be used requiring a minimum of personnel exposures.

2.4 Shielding Design Tests

Special tests and radiation measurements on shielding design were conducted by the Bettis Laboratory in Pittsburgh using the capability and technology that has been developed at the NRTS using TLD.

2.5 Independent Measurements Program

It was found that an obsolete and unused personnel monitoring badge could be modified by means of a new TLD retainer insert for use in the Independent Measurements Program. This modified metal badge is better suited to the

environmental conditions than the standard personnel monitoring (NRTS) badge previously used. The new TLD insert is reusable and enables a 50% reduction in processing time. The badge loss due to the harsh environmental conditions has been virtually eliminated.

The present program utilizes five badges at each of several locations surrounding the facility being monitored. Twenty additional badges are placed in a clean area in the same locale. These badges are used to determine backgound levels and for calibration dosimeters when the badges are returned for evaluation.

Each badge (see Figure 5) contains a TLD insert containing one unshielded and one shielded ^{7}LiF cut ribbon, and one shielded and one unshielded $CaF_2:D_y$ cut ribbon. At present the ^{7}LiF is used for the radiation measurement and the $CaF_2:D_y$ is used to accumulate experimental field data.

3. RESEARCH AND DEVELOPMENT PROJECTS IN DOSIMETRY

3.1 Radiation Effects (J. P. Cusimano, R. Guffey)

A project to study the effects of radiation on flour beetle larvae in closed population systems was performed at the NRTS by Dr. Garth Kennington, of the University of Wyoming, under Associated Western Universities sponsorship. $CaF_2:D_y$ 1 x 6 mm square rod TLD's were used in the initial experiments since they were the same physical size as the larvae. In succeeding experiments, energy independent ^{7}LiF 1 x 6 mm round rod TLD's were used, along with the energy dependent $CaF_2:D_y$ rods, to obtain a more exact dose measurement by comparing the energy dependent and the energy independent TLD's. Exposures ranged from approximately 40 mR to 6.1 R over a five-week period, in various volumes of closed populations.

3.2 Neutron TLD Investigation (J. P. Cusimano)

Research efforts centered around various TLD materials developed by Harshaw Chemical Company that might have potential as a TL neutron dosimeter. Lumiphors such as $CaF_2D_y:Na$, $CaF_2:Mn:Na$, $CaF_2:Mn:U$, $CaSO_4:Mn:U$, and $CaSO_4:Mn:Ma:U$ were investigated to determine the effects of a high thermal neutron cross section material and a fissionable material on the lumiphor response. Most of the materials had no substantial neutron increase. The uranium-containing lumiphors showed some promise, but had such a high dose from the uranium decay and spontaneous fission that much more investigation would be required to determine their usefulness for personnel dosimetry purposes. Work is continuing in the study of the characteristics of newly developed lumiphors.

3.3 CaF_2:Mn Study (J. P. Cusimano)

A preliminary study to determine the fade characteristics, energy-dose response, and other radiation effects of $CaF_2:Mn$ was begun in 1969. The information is needed to yield more reliable results from special in-core radiation measurements at the ATRC and ETRC (Advanced Test Reactor

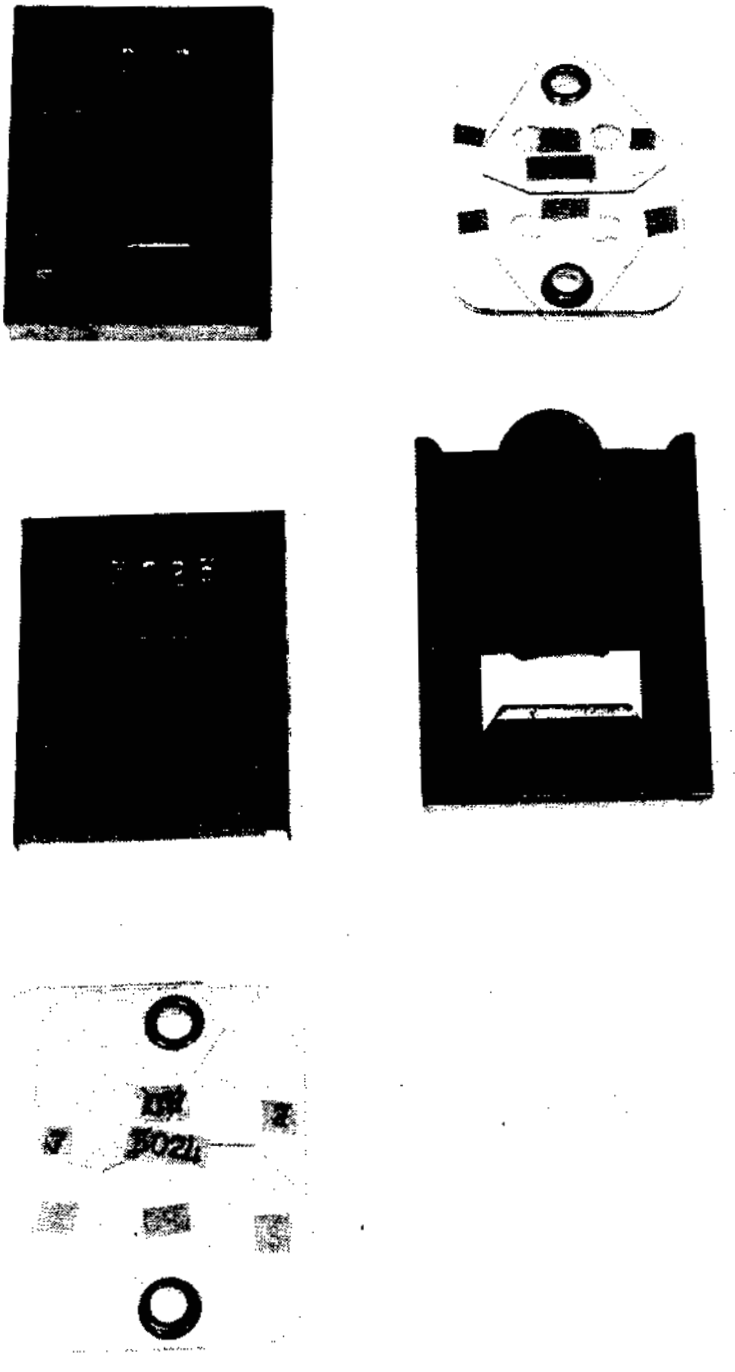


Fig. 5 ID thermoluminescent badge for environmental low level measurements.

Critical and Engineering Test Reactor Critical Facilities). The method of using TLD as compared to ion chambers appears to be much more reliable and economical in determining the effects of gamma heating in reactors.

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

Due to the sudden and unexpected loss of our regular supplier of personnel dosimetry film, increased effort was devoted to design, build, and test a thermoluminescence dosimetry (TLD) system capable of adequately monitoring the approximately 3,000 NRTS personnel currently using film. Since no TLD system presently in existence compares favorably with film dosimetry spectrometric capability in mixed radiation fields, several innovating and unique TLD concepts are under study as a possible replacement system.

3.5 X-Ray Facility Development (J. P. Cusimano, R. Guffey)

Work has continued in developing the capability to produce discrete energy X-rays and filtered X-rays. K-fluorescent targets have been prepared having energy yields in the range from 8 to 77 keV, with dose rates varying from 9 to 40 mR/min at 30 cm distance from the target. The current work is to extend the mono-energetic range to 100 keV and to develop techniques for producing filtered X-rays up to 230 keV with high yield dose rates.

3.6 Electronic Data Processing (V. D. Watkins, J. McDaniel)

Two special computer programs were prepared for the Navy at the Naval Reactor Facility. One program lists exposure by quarter, NRTS-to-date, and lifetime-to-date. This program can also be used for other NRTS contractors. The second program provides the Navy with their annual exposure report in the format required by Navy regulations. Several man-days were required for checking Navy medical and radiation records to set up the program and ensure proper operation.

Personnel at the Computer Science Center of the Idaho Nuclear Corporation converted the dosimetry recordkeeping programs from the IBM 7044 computer to the IBM 360/75 computer. This conversion required the development and learning of new procedures and submittal requirements.

Interfacing of the magnetic tape transport to the automatic film reader was completed and checked out late in 1969. Data accumulated by the automatic film reader is fed to a small data processor (see Figure 6). The data processor performs an edit of the data and causes the valid data to be written on the magnetic tape. All invalid data are rejected and appropriate error messages are provided to allow correction and re-submission. The magnetic tape containing the valid data is then used as input to the central computer for evaluation and report generation.

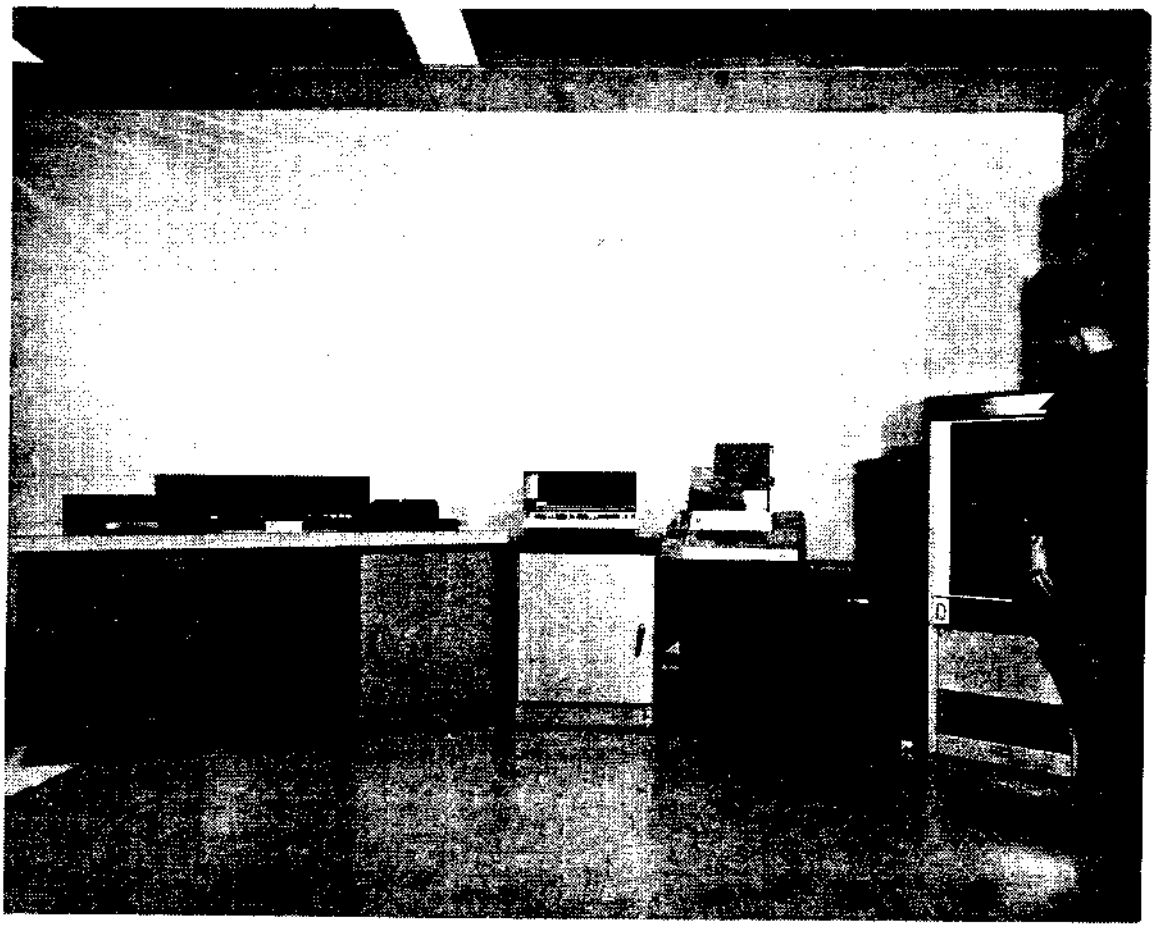


Fig. 6 Film reader with data processor unit and tape transport system.

IV. 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. Atomic Energy Commission medical programs. The AEC Medical Branch is responsible for the planning, operation, and direction of this program for NRTS contractors and 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 (pre-placement, 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 different 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 pre-placement and periodic physical examination form by the majority of NRTS contractors.

The pre-placement questionnaire, which has been in use for three 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 performed annually and a duplicate record is stored as a protection against loss or fire. 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 ID-13 industrial accident reports continues to be a satisfactory method of retaining and reproducing accident and injury data.

Nearly 5,000 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. Additional procedures such as blood chemistry profiles, PAP tests, and pulmonary function testing were added to the periodic physical examination in 1969. Employees of Westinghouse and GE-KAPL from the Naval Reactors Facility (NRF) continued to have their physical examinations at the Central Facilities dispensary, rather than at the NRF dispensary. The decision to

continue in this fashion was reached by Westinghouse management, because of the heavy workload on the single Westinghouse nurse. Whole-body counting of NRF personnel is still performed in the medical van at the NRF site.

During 1969, Idaho Nuclear Corporation was delegated responsibility for supervision of health and safety for construction contractors at the Loss-of-Fluid Test (LOFT) area. As a result, welders and inspectors were evaluated medically for fitness to perform work on a special job at that project. This was the first time at the NRTS that a construction contractor had a significant number of employees examined to determine physical fitness for job assignments.

2. SUMMARY OF 1968 MEDICAL BRANCH WORK STATISTICS

2.1 NRTS Work Population Change

During 1969, a slight decrease in total employment at the NRTS from 5,910 to 5,670 was reflected in a corresponding drop in various medical activity work statistics. However, the work population remained relatively stable, resulting in not only fewer pre-employment physical examinations but also fewer terminations. There was a reduction of one contractor nurse position at the Idaho Chemical Processing Plant (ICPP) which has resulted in one contractor nurse being assigned part-time at the ICPP dispensary and part-time rather than full-time at the Central dispensary.

With the completion of the Computer Sciences Center in Idaho Falls, additional contractor personnel were shifted to Headquarters. There was an increase in Headquarters personnel of 3% and a reduction in site personnel of 2% (not including military personnel) comparing the December 1969 census to that of December 1968.

2.2 Patient Visits to AEC Dispensaries

Total treatment visits at the AEC Central Facilities (CF) and Idaho Falls (HQ) dispensaries decreased from 8,956 in 1968 to 8,233 in 1969 (see Figure 7). While CF dispensary treatment visits dropped 14% in 1969 those in HQ dispensary increased 9%. Although 30% of AEC dispensary treatment visits were made at the HQ dispensary, only 2% of them were for occupational injuries. In contrast, 24% of the treatment visits to the CF dispensary were occupational. Total visits for all purposes decreased from 11,964 to 11,618.

Treatment visits at AEC dispensaries during 1969 were distributed as follows:

(1) Idaho Nuclear Corporation - 55%

(2) Atomic Energy Commission - 20%

(3) Westinghouse Electric Corporation - 7%

(4) Argonne National Laboratory - 6%

(5) Phillips Petroleum Company - 5%

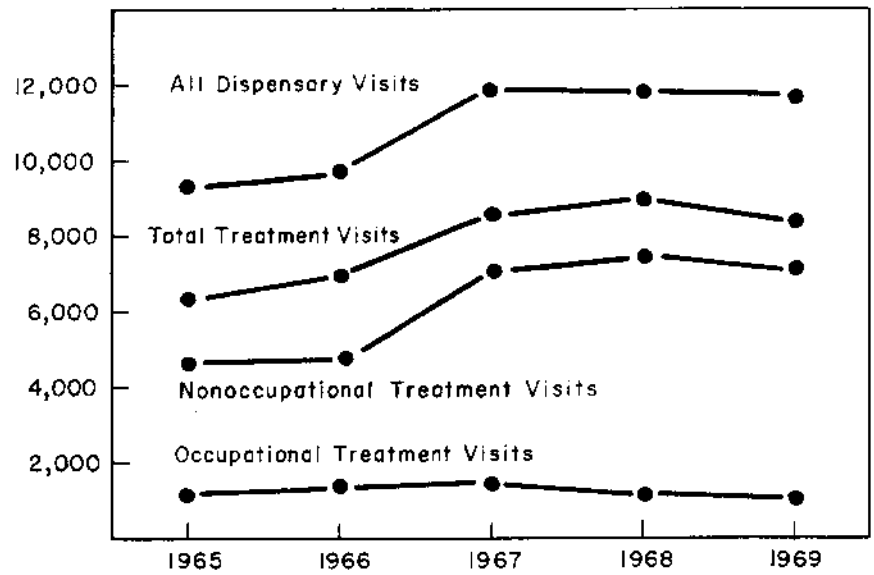


Fig. 7 Central Facilities and AEC Headquarters dispensary visits.

(6) Construction Contractors - 4%

(7) Other federal agencies - 2%

(8) Other - 1%

Distribution of visits by contractor did not change appreciably from 1968.

2.3 Patient Visits to All NRTS Dispensaries and First-Aid Stations

There was a slight decrease in total NRTS dispensary visits from 35,858 in 1968 to 35,476 in 1969 (Table III). Only 14% of the treatment visits (the same percentage as in 1968) were for occupational injuries or illnesses.

Treatment visits at the CF dispensary cannot be compared equally with the other dispensaries, since many of these are referred from plant dispensaries for physician evaluation or for the more extensive examination and treatment facilities at the CF dispensary. Percentages of total treatment visits at area dispensaries for occupational injuries were suprisingly uniform (range, 11% to 14%), with the exception of HQ (2%) and first-aid (34%). After excluding CF dispensary visits the average number of treatment visits per employee for 1969 was four.

2.4 Physical Examination Programs

A slight decrease in the number of termination and pre-placement physicals was offset by a moderate increase in the number of periodic physicals performed (see Figure 8). Total examinations increased from 2,219 in 1968 to 2,248. Sixteen percent of all physical examinations were performed at the HQ dispensary.

2.5 Laboratory and X-Ray

The number of laboratory procedures recorded in 1969 increased markedly as a result of adopting a blood profile procedure in May (see Figure 9). Although

TABLE III

1969 NRTS DISPENSARY VISITS

Dispensary	Occupational			Nonoccupational		Total
	Treatment Visits	Other[a]	Percent	Treatment Visits	Percent	
Central Facilities and Headquarters	1,176	3,395	39	7,047	61	11,618
Chemical Processing Plant	180	49	17	1,094	83	1,323
Argonne National Laboratory	272	90	14	2,179	86	2,541
Test Reactor Area	332	2	14	2,013	86	2,347
Naval Reactor Facility	1,508	2,439	28	10,289	72	14,236
Test Area North	205	87	17	1,473	83	1,765
First Aid	554	--	34	1,092	66	1,646
	4,227	6,062	29	25,187	71	35,476

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

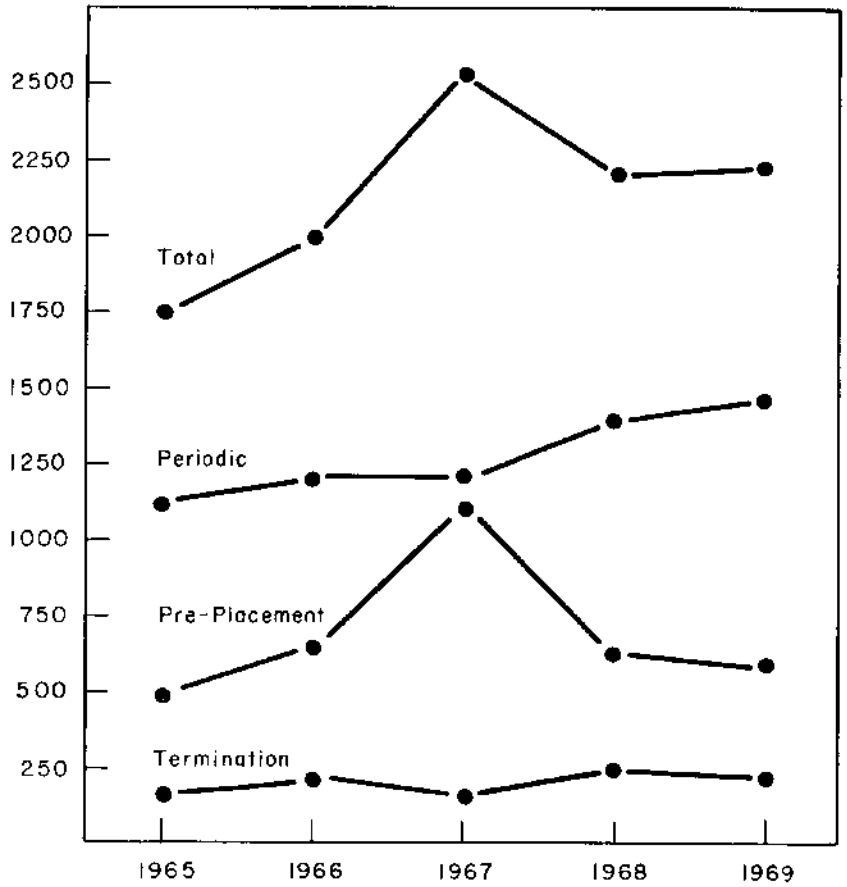


Fig. 8 Physical examinations performed at NRTS.

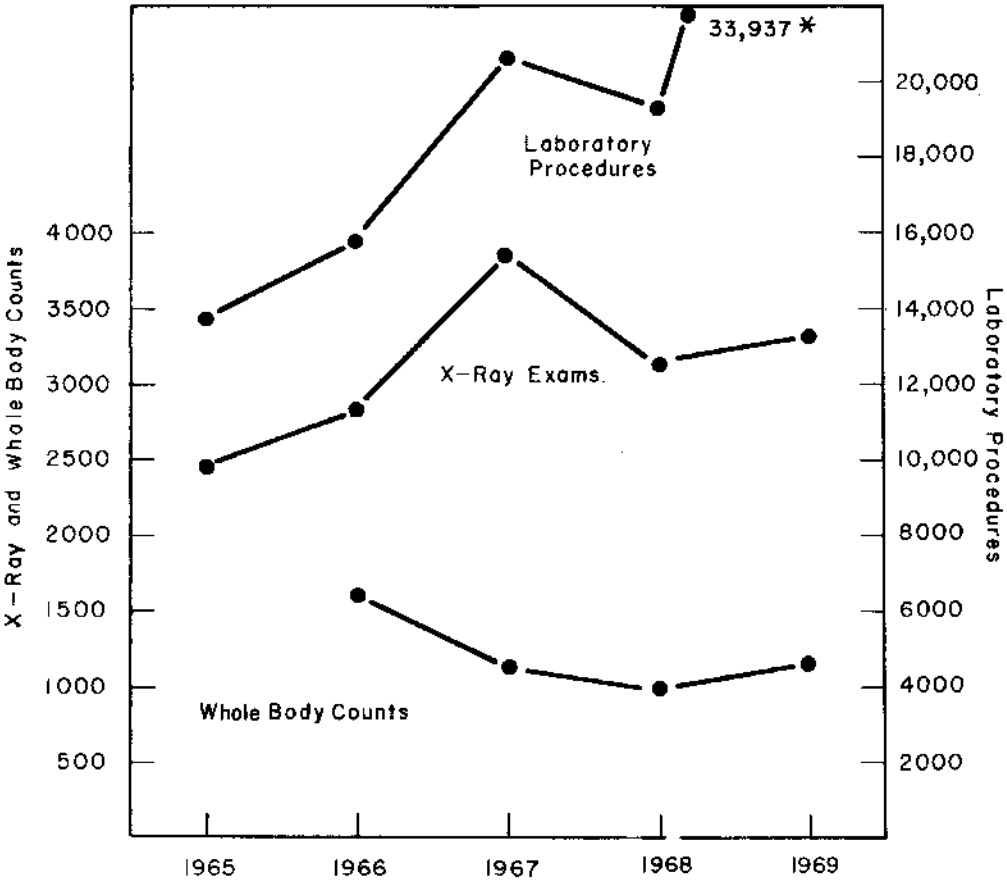


Fig. 9 X-ray, laboratory procedures, and routine whole-body counts.

TABLE IV

ABNORMAL CHEMISTRY TESTS IN 884 EXAMINATIONS

Type Test	Number	Type Test	Number
Alkaline Phosphatase	65	Cholesterol	36
Total Bilirubin	14	Total Protein	5
Albumin	18	Globulin	3
A/G Ratio	8	Total Lipids	160
SGO-T	10	LHD	1
Creatinine	1	Glucose	17
BUN	3	Uric Acid	60

Since these were nonfasting specimens, "abnormal" glucose levels were considered at 150 mg% or above. Although 60 individuals had an elevated uric acid, values of 8.0 mg% or higher occurred in only five cases. Total lipids appeared to be a nonspecific test, since only 32 of the 160 individuals with an elevated total lipid level had an elevated cholesterol. Four persons had an elevated cholesterol without an associated total lipid elevation. Repeat fasting specimens for total lipid values generally gave "normal range" results.

Most abnormal results were only slightly outside the normal ranges. Value of this procedure at this time is inconclusive and data are being gathered in an attempt to determine whether this form of screening is productive enough to continue.

3.2 Whole-Body Counting

During 1969, 1,159 whole-body counts were performed in the medical van. Only 33 individuals were identified with detectible amounts of internal radioisotope contamination. Cobalt-60 was found in 26 individuals, cesium-137 in five, antimony-124 in one, and zirconium-niobium-95 in two (one man had cobalt and zirconium-niobium contamination). No levels in excess of 0.1 μCi were found.

3.3 Pulmonary Function Testing

Routine testing of pulmonary function using the Jones Pulmonor was initiated at time of periodic physical examination on site workers age 40 and older.

Out of 85 routine examinations, five individuals had marked abnormalities in that their one-second vital capacity was less than 90% of the predicted value and their maximal midexpiratory flow rate was less than 70% of predicted. There was no correlation between total vital capacity and one-second vital capacity or maximal midexpiratory flow rate.

A special evaluation of 38 welders for the LOFT project included spirometry. Three individuals in this group had abnormal results. Two of these three

had X-ray findings interpreted as representing emphysema. There was good correlation in this group also between the one-second vital capacity (FEV_1 - forced expiratory volume, one-second) and the maximal midexpiratory flow rate. Poor performance in these parameters suggests emphysema or other obstructive pulmonary process.

3.4 Pre-Employment Medical Questionnaire

This two-page questionnaire is used to develop pre-employment medical information for most job applicants at the NRTS. It identifies past and current health problems, lists the applicant's physician(s), and requires an authorization signature for release of information from physicians and hospitals. Use of this questionnaire has resulted in earlier medical evaluation, access to reliable information from the applicant's physician, economy to the employer, convenience for the applicant, and a medical evaluation that compared favorably with physical examination data obtained after employment.

4. PUBLICATION

G. L. Voelz, "Experience Using a Questionnaire for Pre-Employment Medical Evaluations", to be published in Proceedings of the XVI International Congress Occupational Health, Tokyo, Japan, September 1969.

V. INSTRUMENTATION BRANCH

(M. Wilhelmsen)

1. ROUTINE INSTRUMENTATION ACTIVITIES

1.1 Field Instrumentation Maintenance

A new series of portable radiation survey instruments was added to the instrument pool. These instruments are portable count-rate meters with a range of 0 to 50,000 cpm full scale, utilizing a large, thin-window, pancake type detector. This instrument provides sensitive monitoring of beta radiation for energies down to 40 keV.

During 1969, 2,655 individual repairs and calibrations were performed.

1.2 Laboratory Instrumentation Maintenance

The maintenance of the Health Services Laboratory instruments continues to be a major effort of the Instrumentation Branch. Complexity of the instruments has increased to encompass various types of small computers, multistation calculators, incremental magnetic tape reader/recorders, and special interfacing units. Maintenance problems fall into two general classifications: (a) in-house maintenance wherein HSL personnel trouble-shoot the equipment and make the necessary repairs and (b) maintenance where field-service engineers representing manufacturers are called in as specialists on specific systems. Maintenance by field-service engineers is becoming more universally prevalent with service contracts providing for periodic preventive maintenance.

One facet of instrument maintenance is that of the modification and adaptation of equipment to perform functions different than that for which the equipment was designed. At times a rearrangement of equipment is required in order to combine or build systems of a special nature. These arrangements usually call for design and development of interconnecting electronic "black boxes" for power distribution, signal routing, and program control.

2. SPECIAL INSTRUMENTATION SUPPORT ACTIVITIES

2.1 Manually Operated Alpha Counters (P. R. Boren)

Two manually operated alpha counters were constructed for use in the Analytical Chemistry sample-counting room.

2.2 Dark-Room Water-Bath Heating and Temperature Control (D. Parker)

Two heaters with temperature sensing probes and control units were modified and installed in the dosimetry dark-room to provide better control of the water-bath temperature.

2.3 Assistance for S5G (J. Chambers)

Assistance was provided to personnel at the Naval Reactor Facility (S5G) in repairing and setting up a TMC 400-channel analyzing system.

3. INSTRUMENTATION RESEARCH AND DEVELOPMENT PROJECTS

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

A new portable aerial monitoring system has been completed. This system utilizes a 10-watt transmitter which provides a line-of-sight operating range in excess of 100 miles.

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

The in vivo ^{239}Pu detecting system, which is under development, has reached the stage of acquiring, assembling, and interfacing the various component units which are to comprise the workable prototype. Specially designed, custom-built, permanently filled, gas proportional counters are used to detect the in vivo ^{239}Pu X-rays and to initiate a signal through an analog-to-digital converter (ADC) to corresponding pulse-height memory locations of a small computer. After a designated detecting period of time, the computer will execute a program wherein gross data and background are reduced to net values, which will then be automatically plotted and compared to standard ^{239}Pu curves. All instrumentation, except the special detectors, has been assembled and is in the process of being interfaced and programmed.

3.3 Automatic Changer for Alpha Samples (M. Wilhelmsen, K. H. McGary, P. Boren)

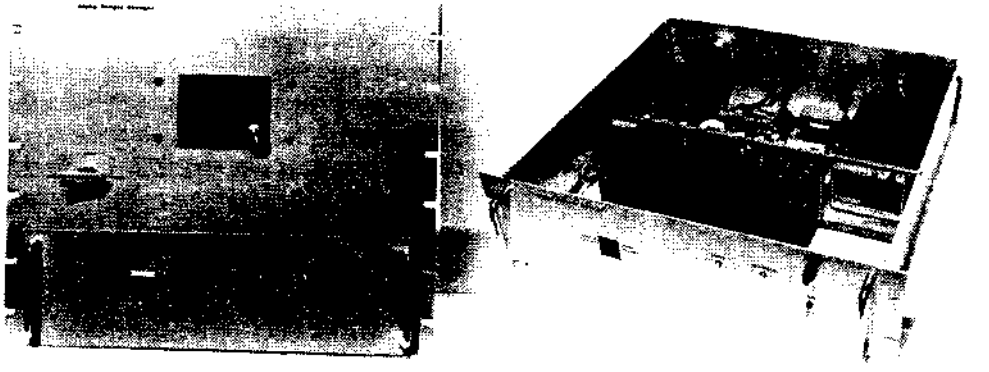
An automatic changer designed and constructed for counting alpha samples, is shown and explained in Figure 10.

3.4 High Speed Telemetry System (D. G. Hill)

A preliminary design and equipment investigation is in process to develop and assemble a high speed telemetry system. This system will utilize R F links and feature computer command control.

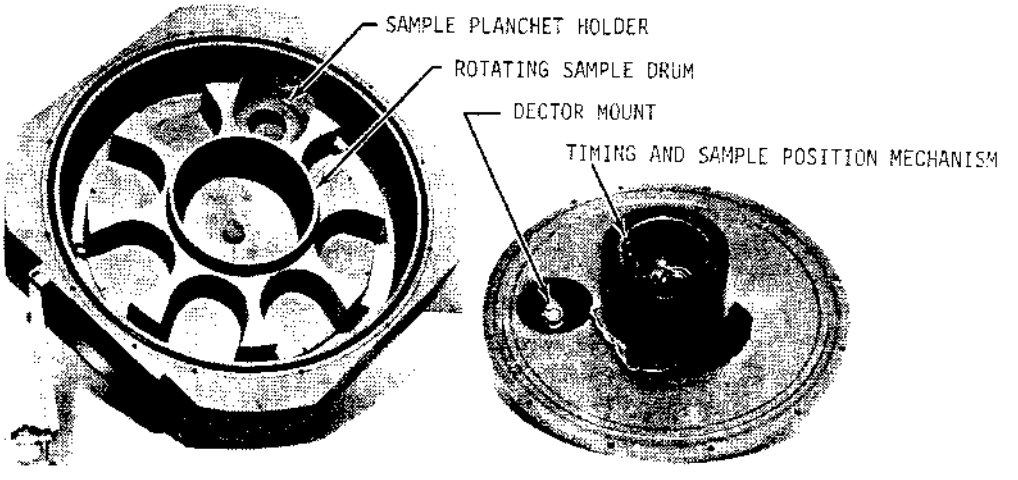
4. PUBLICATION

J. I. Anderson, D. Parker, D. G. Olson, "A Whole-Body Counter with Rotating Detectors", Health Physics, 16 (June 1969) pp 709-717.



ASSEMBLED UNIT

CONTROL ELECTRONICS AND POWER SUPPLY



PICTURED ABOVE IS THE SAMPLE CHANGING MECHANISM WITH THE LID OFF (INVERTED) SHOWING THE EIGHT ROTATING SAMPLE POSITIONS WITH SIX DIFFERENT GEOMETRY LEVELS IN EACH POSITION, AND MOUNTED ON THE LID, THE DETECTORS FOR DETECTING THE SAMPLE POSITION AND GEOMETRY LEVEL. THE SAMPLE CHANGER INTERFACED TO A TMC 400 SPECTRUM ANALYZER IS DESIGNED TO AUTOMATICALLY COLLECT AN ALPHA SPECTRUM FOR A PRESET LIVE TIME COUNTING PERIOD, AND RECORD THE SPECTRUM ALONG WITH THE SAMPLE NUMBER AND GEOMETRY LEVEL ON PUNCHED PAPER TAPE. THE CHANGER WILL COUNT UP TO EIGHT SAMPLES RANDOMLY LOCATED IN THE CHANGER.

Fig. 10 Automatic sample changer for alpha spectrometry.

VI. ANALYTICAL CHEMISTRY BRANCH

(C. W. Sill)

1. 1969 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 and 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 21,000 analyses were made on some 14,000 samples of many different types, and 492 direct in vivo measurements on humans were made. 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.

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

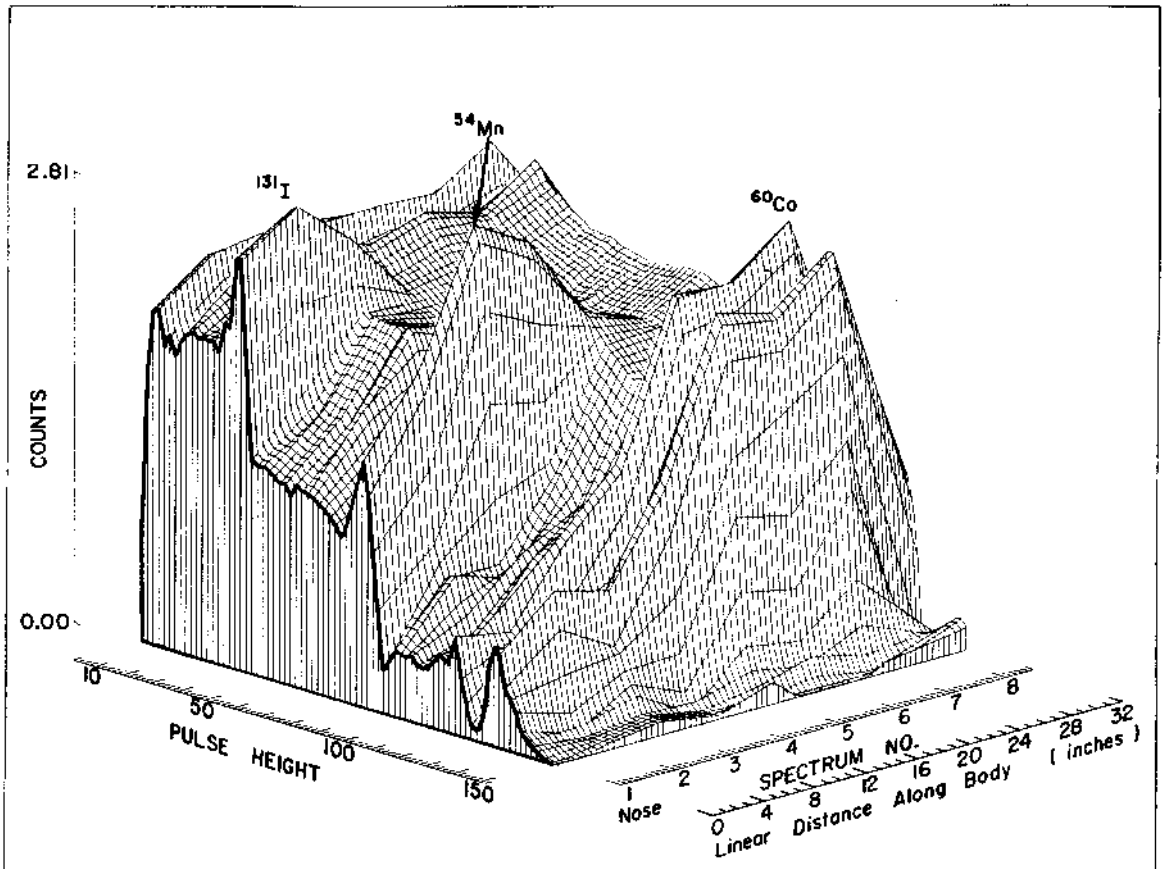
During the past year over 6,000 analyses were performed on more than 2,000 environmental samples, the purpose being to determine the quantities and types of radioactive materials actually being released to the environment. At present the samples are collected around four major licensed nuclear facilities in the United States: a nuclear fuels chemical reprocessing plant, a boiling water power reactor, a scrap recovery-fuel fabrication plant, and a commercial radioisotope production facility. Not only are gross alpha, beta, and gamma analyses routinely performed on every sample, but in addition, specific isotopic analyses are made when the gross alpha, beta, or gamma is sufficiently high to require determination of the specific nuclide or nuclides present.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Whole-Body Counting (J. I. Anderson, B. B. Barnett)

During 1968, several new computer programs were developed for reducing the large volumes of various types of data generated from the rota-scan whole-body counter. The major effort in 1969 was to test and refine these new programs. Each program was tested under conditions which might foreseeably arise in routine operation.

Many different types of plots can be produced by computer processing of the counting data from the rotational whole-body counter. Up to 4,096 numeric values are accumulated by a multi-channel analyzer to localize and quantify the specific nuclides in the human body. Computer techniques are used to reduce and plot this voluminous data as illustrated in Figure 11.



THIS ISOMETRIC PLOT SHOWS THE RESULTS FROM SCANNING THE BODY WITH SOURCES OF ^{131}I, ^{54}Mn, AND ^{60}Co POSITIONED IN THE THYROID, LUNGS, AND LOWER GI TRACT, RESPECTIVELY. RELATIVE INTENSITY OF THE GAMMA RAYS FROM EACH NUCLIDE ARE DISCERNIBLE FROM PEAK HEIGHTS ON THE VERTICAL SCALE OF THE PLOT. THE POSITIONS OF THE PEAKS ON THE PULSE-HEIGHT SCALE ARE USED TO IDENTIFY THE NUCLIDES, AND THEIR POSITIONS ON THE SECOND COORDINATE SHOW THE LINEAR DISTANCE ALONG THE BODY WHERE EACH NUCLIDE IS DEPOSITED. EIGHT SPECTRA WERE ACCUMULATED WHILE THE DETECTOR ROTATED HELICALLY 8 TIMES AROUND AND MOVED 32 INCHES ALONG THE BODY.

Fig. 11 Isometric plot of whole-body counter.

A few NRTS employees found to have low body burdens of gamma-emitting radionuclides were examined by the new techniques. The patterns of distribution were quite satisfactorily determined by use of the rota-scan whole-body counter and the supporting computer programs. At the end of the year all of the computer programs were finalized and documented.

Calibration curves were empirically determined for total body distributions and for lung burdens.

The rotational whole-body counter was modified so that the subject could be placed in a snug-fitting plastic tube rather than on the stretcher. This modification allows the detectors to be moved in closer to the body which improves both sensitivity and counting configuration.

2.2 Analysis of Luminescent Source by Liquid Scintillation Counting (D. G. Olson)

A procedure was developed for determination of tritium by scintillation counting of the luminescent material used to illuminate the dial of a hand compass. Care must be taken to destroy all of the phosphoresce before attempting to count the sample in the liquid scintillator. Otherwise, the luminescence jams the counter. By using perchloric acid, the luminescent material could be decomposed completely in a closed system without loss of tritium.

2.3 Recoil Studies (C. W. Sill, D. G. Olson)

A thorough study of sources and composition of recoil contamination of solid state detectors was made for all four of the long-lived radioactive series in relation to the composition of the source, the length of exposure, the decay time before counting, and the counting time. A pseudo-recoil effect of ^{210}Po due to its own inherent volatility was also demonstrated.

Recoiling atoms can be prevented from reaching the detector by maintaining 12 $\mu g/cm^2$ of air between the source and the detector. The loss of alpha resolution is only 1 to 2 keV, while the recoil contamination is reduced by a factor of 10^3. However, even though the recoil atoms have been brought to rest by the absorber, a small negative potential must be applied to the source plate to prevent the charged atoms from being attracted to the charged detector, effectively restoring the possibility of contamination.

2.4 Gamma Detector Systems (D. G. Olson)

The proper selection of a detector system can eliminate time, lower the detection limits, and improve the reliability of analytical results. A study is being made to determine the figure-of-merit for various gamma-ray detectors. The following statements appear to be true: (a) gross systems are the least-specific, the least sensitive, the least expensive, and the easiest to maintain; (b) NaI(Tl) systems are semi-specific, moderately sensitive, moderately expensive, and easy to maintain; (c) Ge(Li) detectors are highly specific, highly sensitive, highly expensive, and the hardest to maintain.

2.5 Carbon-14 in Environmental Samples by Liquid Scintillation (R.B. Randolph)

A method was developed for the determination of ^{14}C in various environmental samples including air, water, and vegetation. Because the weak betas of

^{14}C (0.156 MeV) are not detected by normal beta counting procedures, an analysis specific for ^{14}C requires use of liquid scintillation counting. Preparation of water and vegetation samples for counting involved steps to ensure complete degradation followed by generation of $^{14}CO_2$ and collection in $Ba(OH)_2$ as the carbonate. The $BaCO_3$ is suspended conveniently in a scintillation gel and counted. Further work is to be conducted on preparation of air samples for ^{14}C analysis.

2.6 Determination of All Alpha Emitters on Barium Sulfate (C. W. Sill, R. L. Williams)

The previous procedure for precipitation and determination of all alpha emitters on barium sulfate was applied successfully to a large variety of environmental and process samples. Particularly, the application to the "summation rule" required by federal regulations was demonstrated.

2.7 High Resolution Alpha Spectrometry on Cerium Hydroxide (R. L. Williams)

A method has been developed whereby every alpha emitter, except uranium, that is carried on barium sulfate can be dissolved in alkaline EDTA and precipitated on 0.2 mg of cerium. The cerium hydroxide will carry better than 93% of each of the emitters and when deposited uniformly on a two-inch plate, will give a spectral resolution of from 39 to 55 keV. The method is rapid and reliable and can be used on any samples in which barium sulfate is used to collect the alpha activity.

2.8 Radiochemical Determination of Alpha Emitters from Large Samples of Bone Ash (R. L. Williams)

A study was carried out to determine if alpha activity could be recovered from large samples of bone ash. In spiked samples of from 10 to 100 g, the recovery was better than 85% for uranium and the transuranium elements. The samples were dissolved in nitric acid and the activity was removed on repeated precipitations of ferric phosphate.

2.9 Determination of Enriched Uranium and Plutonium in Biological and Environmental Samples (K. W. Puphal, D. R. Olsen)

A method was developed for the routine analysis of enriched uranium and plutonium in urine, feces, air dusts, soils, fish, vegetation, and waters by an extraction with Aliquat 336 from an aluminum nitrate system. Separation from a nitrate system minimizes the extraction of many interfering elements. The separated sample is electrodeposited onto stainless steel to determine the alpha counting rate and make isotopic identification by high resolution alpha spectroscopy.

2.10 Gross Alpha Research (K. W. Puphal, D. R. Olsen)

The gross alpha concept has been extended to include the extraction of all the actinides from aluminum nitrate into a quaternary amine. The method has the distinct advantage of using a single extraction for all valences from systems that normally preclude the use of other gross alpha methods. Elements such as iron and the alkaline earths offer a minimum of interference. Application

of this method includes urine, feces, fish, air dusts, water, soils, and vegetation.

2.11 Electrodeposition Procedure for High Resolution Alpha Spectroscopy (K. W. Puphal, D. R. Olsen)

A method was developed for the electrodeposition of the actinide elements, bismuth and polonium, onto stainless steel from a mixed oxalate-chloride electrolyte. The method incorporates a chelate and fluoride to prevent losses due to hydrolysis and the presence of certain interfering cations. Samples such as urine, feces, vegetation, fish, air dusts, and soils were electrodeposited after chemical separation to determine their isotopic abundance. The deposited samples were also used to determine gross alpha counting rates.

2.12 Sequential Radiochemical Determination of ^{226}Ra, ^{228}Ra, ^{227}Ac, and ^{230}Th in Environmental Waters, Air Dusts, Ores, and Uranium Mill Process Wastes (D. R. Percival, D. B. Martin)

A procedure for the sequential determination of ^{226}Ra, ^{228}Ra, ^{227}Ac, and ^{230}Th has been developed which permits their detection in a single sample at 0.1 to 0.001 of the concentration guides specified by federal regulations for uncontrolled areas. The procedure is versatile since any one or more of the radionuclides may be excluded from the analysis by omitting certain independent steps, thus shortening the working time proportionately. Overall recoveries through the entire procedure are 99% for radium and 95% for actinium and thorium. Accuracy, precision, and the effects of both chemical and radiochemical interferences were studied.

2.13 Simplified Direct De-Emanation Method for the Determination of ^{226}Ra (D. R. Percival)

A direct de-emanation method for the specific determination of ^{226}Ra was developed which is more convenient to use and less time-comsuming than existing methods. High precision and accuracy are achieved without the use of drying agents, ascarite, and special pressure adjustments. The procedure is routinely applied to the determination of ^{226}Ra at concentrations as low as 3×10^{-10} μCi/ml in samples submitted by the Division of Compliance.

2.14 Studies on the Adsorption and Desorption of ^{222}Rn on Activated Charcoal (D. R. Percival)

Most existing methods for the isolation of ^{222}Rn from large volume air samples involve its adsorption on activated charcoal maintained at a temperature of -80°C in a dry-ice-acetone bath. Studies at this laboratory, however, have shown that the ^{222}Rn in up to 40 liters of air is quantitatively adsorbed on 10 g of activated charcoal maintained at 0°C in an ice-water bath. Besides the obvious advantages of using ice water rather than dry ice acetone, the adsorption of unwanted gases is greatly reduced at 0°C.

Attempts to obtain high precision data using 10^3 to 10^4 pCi ^{222}Rn standards were frustrated due to incomplete desorption of radon from activated charcoal. Desorption efficiency at 500°C was found to be inversely proportional to both the quantity of charcoal used and the total quantity of radon adsorbed. Purges

of 10 g of charcoal at 500°C with even 25 liters of helium or nitrogen resulted in the recovery of only 98% of the radon from a 10^4 pCi standard. Most air samples, however, do not contain enough radon to cause problems with its recovery from activated charcoal. In special cases, smaller samples can be taken to limit the total quantity of radon.

2.15 Retention of ^{222}Rn in Mylar and Saran Bags (D. R. Percival)

The use of collapsible Mylar bags in the collection of air samples for ^{222}Rn analyses was established in 1968 for an extensive air sampling program. Experience with the bags over prolonged periods of use showed that they developed small holes which were difficult to detect. The presence of undetected holes caused decreases in ^{222}Rn concentration due to preferential loss of radon or dilution of the radon in the bag by external air. Preliminary studies with bags made of Saran indicate that this material retains radon with little loss over a ten day period, and therefore might be substituted for the more expensive and leak-prone Mylar.

2.16 Internal Dosimetry (D. R. Percival)

Further development and refinement of methods for the in vivo determination of radionuclides could be greatly facilitated by studying selected radionuclides which have been ingested by human volunteers. Therefore, estimates of the maximum allowable activity for a single ingestion, predictions of the activities reaching various body organs, dose estimates per μCi ingested, and recommendations for administration were made for a number of selected radionuclides.

2.17 Factors Affecting Alpha Particle Counting Efficiency (D. R. Percival)

High precision and accuracy in the determination of disintegration rates from alpha counting data require a sound knowledge of the factors affecting counting efficiency in a given instrument. Alpha particle backscattering, uniformity of source distribution, self-absorption, alpha particle energy, and instrumental differences between counters were studied and their effects determined.

2.18 Special ^{222}Rn Analyses (T. D. Filer, D. R. Percival)

Sixty ^{222}Rn analyses were performed on 35 air samples collected at uranium mills in Wyoming and New Mexico. Radon concentrations much higher than those usually present in the air of uncontrolled areas were found but only three samples exceeded the 100 pCi/l working level for controlled areas.

2.19 Determination of ^{125}I and ^{131}I in Bovine Thyroids (L. E. Howard)

Two experiments were conducted using six cows in the Controlled Environmental Release Tests (CERT). In CERT 25, 200 μCi of ^{131}I was given orally to the cows; 12 days later (CERT 26), the cows were given 500 μCi of ^{125}I.

A thyroid counter was designed, built, and calibrated to simultaneously determine the uptake and retention of the two radioiodine isotopes in the bovine thyroids.

Apparently the effective half-life of the radioiodine in the thyroid could be reduced 50 ± 20% by giving the cows 10 grams of stable sodium iodide daily beginning 12 days after the administration of ^{125}I. However, only three cows were used in the test and the stable iodine was given to them for only seven days, so inadequate data are available to make positive conclusions.

2.20 Separation of ^{225}Ac from a Mixture of ^{229}Th, ^{228}Th, and Daughters (D. B. Martin)

A method was developed to separate ^{225}Ac from ^{229}Th, ^{228}Th, and their daughters. The ^{225}Ac is first carried on lead sulfate and then extracted from an ammonium diethylenetriaminepentaacetate solution of the lead with bis (2-ethylhexyl) phosphoric acid. The ^{225}Ac was used for recoil studies.

2.21 Purification of Cerium Carrier (D. B. Martin)

Cerium used to precipitate cerium oxalate to carry ^{227}Ac for alpha counting needs to be free of alpha-emitting contaminates. The cerium was oxidized to Ce(IV) with divalent silver in 4N HNO_3, extracted into bis(2-ethylhexyl) phosphoric acid, and stripped into 4N HNO_3 by reducing to Ce(III) with hydrogen peroxide. Since the yield is about 99%, the Ce carrier need not be standardized.

2.22 Separation of ^{228}Ra and ^{228}Ac Tracers from Old Thorium Salts (D. B. Martin, D. R. Percival)

A method was developed to separate 100 grams of ^{232}Th from its carrier-free daughters, ^{228}Ra and ^{228}Ac. The thorium is extracted into 1.5 liters of 50% bis(2-ethylhexyl) phosphoric acid (n-heptane). The ^{228}Ra and daughter, ^{228}Ac, are used as gamma tracers for radium and actinium studies.

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

Strontium-90 was determined in various media to certify that AEC contractors and licensees were complying with federal regulations. Various procedures were investigated in order to find quicker methods of determination for ^{90}Sr in diversified media.

2.24 Radiochemical Analysis of Large Samples of Oysters (C. P. Willis)

A procedure has been developed for the radiochemical analysis of up to 1000 g of oysters or other biological material. The sample is first gamma counted for gamma-emitting isotopes, some of which may be lost in the decomposition. The oysters are then drained and weighed. Sulfuric, perchloric, and nitric acids are then added and the solution is heated until all the organic matter has been destroyed. Strontium is then separated from the inorganic salts remaining to determine the ^{90}Sr content. A barium sulfate precipitation is made to remove all alpha-emitting isotopes and the barium sulfate is counted for a gross alpha determination. If a significant alpha count is detected, an alpha spectrum is taken for identification of the isotopes. Oyster samples from Humboldt Bay, California have been analyzed and the only radioisotope found was ^{210}Po.

2.25 Spontaneous Deposition of ^{210}Po on Silver Discs (R. P. Bernabee)

Various parameters for the deposition medium of ^{210}Po, such as acid concentrations, temperature, and length of deposition, have been investigated. Most efficient deposition proceeds from an acid concentration of 0.5N HCl at 95°C for 90 minutes.

Sample decomposition is one of the main problems encountered during analysis of ^{210}Po due to the relatively high volatility of ^{210}Po. Both sodium peroxide and pyrosulfate fusions have been employed for sample decomposition with success. Less than 1% loss can be expected when using either of these two methods.

When separation of ^{210}Po from serious interferences is necessary, extraction from an alkaline citrate-cyanide medium can be accomplished with dithiozone in $CHCl_3$. Greater than 99% extraction is achieved. The only elements to interfere with deposition are Hg, Ag, Pb, Bi, Au, and ferric iron. The two most serious interferences are ferric iron and lead.

Extremely low level determinations are possible with present procedure. Detection limits on the order of 10^{-16} μCi/ml are possible on 1000 M^3 air samples and a count time of 1000 minutes. Such determinations are being employed on air dust filters for the state of Idaho. Detection limits used on other sample types are 0.1 MPC.

Counting efficiency for the one-inch discs have been determined using the 4π counting concept. Overall counting efficiency is 46.2%.

The procedure has been applied to water, soil, air dust, vegetation, and high protein samples. It offers several advantages over other procedures in that interferences are almost nonexistent and easily eliminated if present. No radon daughter buildup has been detected which eliminates time necessary for their decay before counting. No extensive absorber correction fractions are needed since absorber is absent. All interferences except ferric iron and lead are eliminated by reduction with hydrazine dihydrochloride. Only trace amounts of lead are deposited, and ferric iron is eliminated by complexation with fluoride ion.

Routine analyses consist of ^{210}Po determinations and natural uranium determinations via the fluorometric procedure. Samples from Compliance - Region III usually receive both.

2.26 The Fluorometric Determination of Thorium (T. D. Filer)

A fluorometric method for the determination of thorium was developed using 3,4'7-trihydroxyflavone. This procedure can detect quantities of thorium larger than 0.03 μg and is virtually free of a serious beryllium interference that troubled previous procedures.

2.27 The Fluorometric Determination of Zirconium (T. D. Filer)

A fluorometric method for the determination of zirconium is being developed using 3,4',7-trihydroxyflavone. This procedure shows advantages over

previous procedures because of the simplicity of the fluorescence development and its lack of serious interferences.

2.28 The Fluorometric Determination of Germanium (F. D. Hindman)

A fluorometric method for the determination of germanium was developed using 4'-dimethylamino flavone. This procedure can detect germanium larger than about 0.02 μg, and the only interfering elements are titanium and boron.

2.29 Radiochemical Determination of ^{231}Pa and ^{210}Po in Environmental and Biological Materials (C. W. Sill)

The subject procedure has been largely completed and a manuscript is being prepared for publication.

3. PUBLICATIONS

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 Physics, 16, n 3 (March 1969) pp 325-332.

C. W. Sill, "An Integrating Air Sampler for Determination of ^{222}Rn", Health Physics, 16, n 3 (March 1969) pp 371-377.

J. I. Anderson, D. Parker, D. G. Olson, "A Whole-Body Counter With Rotating Detectors", Health Physics, 16, n 6 (June 1969) pp 709-717.

S. D. Shearer, Jr., C. W. Sill, "Evaluation of Atmospheric Radon in the Vicinity of Uranium Mill Tailings", Health Physics, 17, n 1 (July 1969) pp 77-88.

C. W. Sill, "Separation and Radiochemical Determination of Uranium and the Transuranium Elements Using Barium Sulfate", Health Physics, 17, n 1 (July 1969) pp 89-107.

C. W. Sill, R. L. Williams, "Radiochemical Determination of Uranium and the Transuranium Elements in Process Solutions and Environmental Samples", Anal. Chem., 41, n 12 (October 1969) pp 1624-1632.

D. G. Olson, "In Vivo Determination of ^{90}Sr by Analyzing Bremsstrahlung from the Skull", being published in the Proceedings of the Midyear Topical Symposium sponsored by Health Physics Society, January 29-31, 1969.

VII. ENVIRONMENTAL BRANCH

1969 ANNUAL REPORT

1. ROUTINE ACTIVITIES

1.1 Environmental Monitoring

The concentrations of radioactive materials in air are monitored continuously by drawing air through particulate and charcoal filters at eight on-site and eight off-site locations. These filters are changed weekly and counted for long-lived alpha and beta radioactivity. In addition, a network of 18 telemetering stations (six on-site and 12 off-site), designed primarily for emergency situations is operated on a continuous basis. Filterable airborne radioactivity and the external gamma exposure rate are monitored continuously at each station. All stations are interrogated hourly and the data are telemetered to the Laboratory where they are recorded for subsequent analysis. 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 on-site were made.

Weekly composite samples of milk from the Idaho Falls milk shed are collected and analyzed for ^{131}I and ^{90}Sr. Samples of wheat are collected throughout southeastern Idaho at harvest time and are analyzed for ^{90}Sr.

Ground water is monitored routinely to determine the fate of radioactive

Laboratory, assistance in establishing each survey, interpretation of the data, and preparation of reports. Routine measurements are currently being made around a nuclear fuels reprocessing plant, a boiling water power reactor, a scrap recovery and fuel fabrication plant, and a radiochemical supply laboratory. Preliminary sample collection at the site of a pressurized water power reactor was completed and development of a computer program for handling the data from all surveys was partially completed. Measurements have shown that these facilities are complying with federal radiation standards, although above-background concentrations in air and water have been measured at a few of these locations. Thermoluminescent dosimeters placed around one plant location recorded unusually high exposure rates that required corrective action.

1.3 Waste Management

The Branch is responsible for developing guides and regulations for management of wastes at the NRTS and provides consulation necessary for their implementation. NRTS waste disposal activities are recorded and periodically reported.

During 1969, public concern about the environmental effects of radioactive waste disposal increased. Special effort was required for the preparation of programs and information describing NRTS waste management practices for presentations before the National Academy of Science Committee, the Idaho State Board of Health, and at other in-house conferences.

1.4 Particle Sizing and Counting

The Branch provides a particle sizing and counting service for NRTS contractors. During 1969, air samples from Naval Reactor Facility work areas were counted for asbestos particles, and samples from boiler stack exhaust air were sized and counted for Idaho Nuclear Corporation.

1.5 Emergency Response and Preparedness

The Branch is responsible for evaluating hazards to on- and off-site personnel resulting from planned and unplanned releases of radioactivity to the environment, and for acting to minimize personnel exposure in the event of a radiological emergency. A group of trailers (Trailer City) is maintained in a state of readiness for response to an emergency at any on-site area. Branch personnel are available to operate Trailer City and to assist contractor personnel when the need arises. The Branch is also responsible for maintenance of the emergency kits of equipment used by ID Radiological Assistance Teams.

1.6 Health Physics

The Branch is responsible for the protection of Laboratory and other ID personnel from unwarranted radiation exposure. Routine contamination and direct radiation surveys of AEC facilities at the NRTS are performed, and radioactive shipments to and from the Laboratory are monitored. Disposal of radioactive waste from the Laboratory is arranged as required. Measurements of face velocities of fume hoods in the Laboratory and Dispensary are made

periodically. During 1969, several special fume hood surveys were required as part of an effort to improve air flow patterns within the Laboratory.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 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 behavior of ^{131}I in the milk-food chain has been studied extensively (AEC Report IDO-12065). Investigations into the behavior of radioactive particles and of other radioactive gases have been started and will become the dominant aspect of this program. A topical summary for 1969 follows:

1. Effect of Stomatal Opening on Transfer of $^{131}I_2$ to Grass. (D. R. Adams)

   A new technique for measuring stomatal opening was tested and subsequently employed during a series of laboratory experiments with Manchar Bromegrass. Phenylmercuric acetate treatments were found effective for regulating stomatal opening but the transfer rate of I_2 to treated grass was more than 30 times that for untreated grass. Hence, ordinary pasture grass is definitely not a perfect sink for I_2. The transfer rate was shown to be proportional to the stomatal opening (controlled by varying lighting conditions). For fully open stomata, about 40% of the total transfer can be attributed to adsorption by the leaf surfaces.

2. Environmental Chamber. (C. A. Pelletier, R. McBride, J. B. Echo)

   Construction of the environmental chamber was completed during 1969. Installation of six-inch deep honeycombs at both ends of the experimental section was completed. Design of additional lighting equipment and air conditioning for the static section was completed. Preliminary velocity measurements were made and profile generator design was begun.

3. Aerosol Generation, Release, and Analysis. (R. L. Bangart, B. W. Mortensen, J. B. Echo, P. G. Voilleque')

   Photomicrographic equipment was received, installed, and tested. A fluid atomization aerosol generator was purchased, tested, and used to produce a ^{51}Cr aerosol for a deposition experiment at the Experimental Dairy Farm (EDF). The median deposition velocity of the particles was 0.24 cm/sec (particle size not yet available). A spinning disk aerosol generator was procured.

4. Bovine Metabolism of Radioiodine. (P. G. Voilleque', R. L. Bangart, D. R. Adams, R. McBride)

Best-fit rate constants for the metabolic model (AEC Report IDO-12065) were refined. D. J. Cresswell (Associated Western Universities appointee from Idaho State University) developed an improved rate-constant evaluation procedure for the model.

Two experiments, CERT-25 and -26, were performed at the EDF in cooperation with B. R. Moss of Montana State University as part of a study of the metabolism of radioiodine in cows fed Sudan grass. Previous experiments had shown that when iodine-131 on Sudan grass was ingested, only one third as much iodine-131 was transferred to milk as when iodine-131 on pasture grass was ingested. CERT-25 and -26 were carried out to isolate the cause of the reduction.

2.2 Injection of ^{133}Xe into the Lithosphere (B. L. Schmalz)

The final report (IDO-12069) for this research project was published in June 1969.

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

The migration of radionuclides in the regolith at the NRTS Burial Ground was studied and results were compared with theoretical predictions. The sorption of radionuclides by soil was studied in the Laboratory using soils and waste solutions from the Test Reactor Area (see Figure 12). Results of this work will be included in a report being prepared on "Distribution of Radionuclides in the Regolith as a Result of Waste Disposal".

The chemical species, concentration limits, and other parameters of the aqueous chemistry of plutonium were studied because of the interest in potential migration of plutonium through NRTS Burial Ground soil.

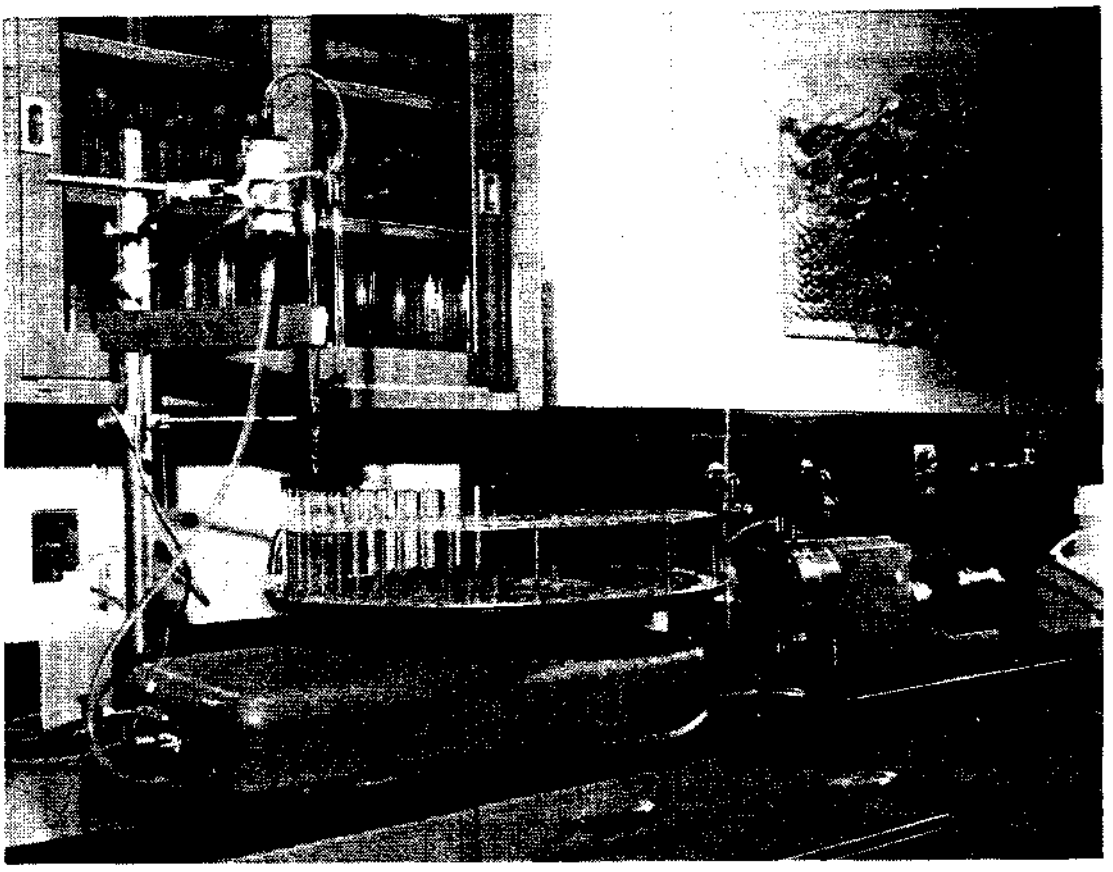
2.4 Tritium Studies (B. L. Schmalz, W. L. Polzer)

A study of the question of selective absorption of tritiated water by minerals was initiated. Preliminary results indicate that aluminum hydroxide may preferentially absorb tritium.

2.5 Sampler Development (J. H. Osloond, J. B. Echo)

Development of a sampler for tritium in air, which is designed to function as part of a low-volume sampler for routine environmental monitoring, was nearly completed. Preliminary testing indicates that a detection level of 10^{-10} μCi/ml will be possible for average sampling conditions.

The problem of finding a suitable filtration medium for ^{203}Hg vapor was studied. A two-inch AC-1 charcoal impregnated filter was found to have a collection efficiency of 77% for ^{203}Hg at an air flow rate of 4 liters/minute.



AN APPARATUS FOR DETERMINATION OF ION EXCHANGE CAPACITY OF A SAMPLE COLUMN OF SOIL. A SOLUTION CONTAINING AN EXCHANGEABLE NUCLIDE IS FORCED UPWARD THROUGH THE SOIL COLUMN BY THE PUMP ON THE RIGHT. AFTER PASSING THROUGH THE SOIL IT IS COLLECTED IN A GLASS FRACTION COLLECTOR. AFTER A SPECIFIC VOLUME IS COLLECTED IT IS AUTOMATICALLY EMPTIED INTO A TEST TUBE LOCATED ON A ROTATING REEL BELOW. AFTER EACH TUBE RECEIVES ITS ALLOTTED VOLUME AN EMPTY TUBE IS AUTOMATICALLY ROTATED INTO PLACE FOR THE NEXT COLLECTION.

Fig. 12 Laboratory apparatus for soil ion exchange studies.

2.6 Comparative Deposition Test (P. G. Voilleque', J. B. Echo)

At the request of ARLFRO-ESSA, techniques for releasing radioactive I_2 and CH_3I at constant rates were established and used for a field comparison of the transfer of I_2 and CH_3I to vegetation and ground surfaces. The I_2 generation technique described in IDO-12065 was improved and the CH_3I generation technique developed at the Idaho Chemical Processing Plant (ICPP) was used. Special sampling trains for differentiating between I_2 and CH_3I, also developed at ICPP, were used for the field test.

2.7 Internal Dosimetry (P. G. Voilleque')

An evaluation of the question of which organ is "critical" for plutonium inhalation exposures was performed using the results of animal experiments described in the literature. The results of this evaluation will be summarized in a paper "The Critical Organ for Plutonium Inhalation Exposures".

2.8 Experimental Cloud Exposure Study (EXCES)

The objectives of this study are to (a) obtain experimental data on build-up factors in air, (b) measure exposure rates from clouds of gamma-emitters under documented meteorological conditions, and (c) develop a predictive model. Idaho Nuclear Corporation personnel are also participating in this study.

During 1969, 12 ion chamber-ratemeter units were obtained, tested, and installed, and additional units were ordered. An aerosol generator for the field release tests was assembled and tested in the laboratory and a cask for shielding the source material prior to release was constructed. Data acquisition equipment for gamma spectrum measurements was obtained, and an analysis of the effect of variations of certain input parameters on the cloud gamma dose computer by the RSAC (Radiological Safety Analysis Computer) code was completed. Several field releases of ^{133}Xe were attempted, but because of unfavorable meteorological conditions, useful data were obtained from only one test. Evaluation of several methods for determining vertical concentrations distributions was begun. The safety analysis report for the field test phase was drafted and reviewed.

3. PUBLICATIONS AND PRESENTATIONS

P. G. Voilleque', "Calculation of Expected Urinary and Fecal Excretion Patterns Using the ICRP Task Group Report on the Human Respiratory Tract", paper presented at the Health Physics Society Midyear Topical Symposium, (January 1969) (to be published in the Proceedings).

J. H. Osloond and D. L. Newcomb, Radioactive Waste Disposal Data For The National Reactor Testing Station, Idaho, IDO-12040, Supplement No. 4 (April 1969).

B. L. Schmalz, Injection of Gas into the Lithosphere at the National Reactor Testing Station, IDO-12069 (June 1969).

C. A. Pelletier and P. G. Voilleque', "The Cycling of Radionuclides on a Dairy Farm", paper presented at The Health Physics Society 14th Annual Meeting (June 1969).

C. A. Pelletier, "The Impact of Fuel Reprocessing Plants and Power Reactors on the Health Physics Profession -- Environmental Aspects", Invited paper presented at The Health Physics Society 14th Annual Meeting (June 1969).

E. H. Markee, Jr, and D. R. Adams, "Some Processes Affecting the Transfer of Radioiodine Gas from Air to Grass", paper presented at the Ninth Conference on Agriculture Meteorology (September 1969).

P. G. Voilleque', "AERIN, A Code for Acute Aerosol Inhalation Exposure Calculations", Health Physics (in press).

VIII. 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 emphasize the effects of disposal of liquid low-level radioactive waste to subsurface water 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.

Study of the ground-water hydrology at the NRTS was continued during 1969. A total of 675 measurements of the water level in about 100 different wells were made to denote changes in water storage in the Snake Plain aquifer and in perched ground-water bodies. About 275 ground-water samples were collected to evaluate water quality changes. Over 700 chemical and radiochemical analyses were performed on these samples. Fourteen wells and ponds were equipped with continuous water-level recorders. Three continuous discharge stations were operated on the Big Lost River and 10 direct stream discharge measurements were made.

About 50 wells were logged with geophysical and radiation probes to evaluate water and rock properties. The project now has the capability of making neutron-epithermal neutron logs. Above the water table, this logging technique can determine the moisture content within a formation. Below the water table, the log can be a measure of formation porosity. Utilizing a three curie ^{241}Am-Be source, this sensitive tool obtains deep lateral penetration of the rocks.

The flow of the Big Lost River below Mackay Reservoir during 1969 was about 387,000 acre-feet. This is the second highest flow during the 53 years of record. It is only about 10,000 ac-ft less than the record set in 1965, and about twice the average flow. The 1969 flow onto NRTS was almost 250,000 ac-ft, higher than in 1965, which made the 1969 discharge a new NRTS record. The effects of this water on the Snake Plain aquifer and on the radioactivity in the aquifer are under investigation. The water level in some wells is the highest recorded in the last 20 years.

2. RESEARCH AND DEVELOPMENT PROJECTS

2.1 Investigations of the Effects of Underground Waste Disposal

The geohydrologic study of the effects of waste disposal to ponds and wells continued. More specific information on the composition of the waste effluent discharged to the Idaho Chemical Processing Plant (ICPP) disposal well was collected. The temperature of the waste water averages near 70°F. A decreasing temperature to the normal 55°F can be traced about 1-1/2 miles downgradient in the Snake Plain aquifer. These measurements are similar to those evaluated in 1960-61. The sodium and chloride contents of the waste

effluent at ICPP are about the same as in 1957-59. The chloride content of water from the Snake Plain aquifer within 5 miles of the ICPP disposal well remained fairly constant for the past 11 years. The pumping from the two supply wells in the Central Facilities Area has a significant influence on the southward migration of ICPP liquid wastes in the aquifer. The tritium component of the effluent is lowered about six fold in the course of 2-1/2 miles of travel from ICPP to the Central Facilities Area. About 20% of the reduction is due to radioactive decay, and 80% results from hydraulic dispersion. The dilution factor of the chloride content of the ground water is about five. A comprehensive analysis of the effects of liquid waste disposal at NRTS is being prepared in a report.

Considerable concern has been expressed about the potential contamination of the Snake Plain aquifer by solid radioactive wastes buried at the NRTS. The status of knowledge of the hydrology and geology of the burial ground was reviewed with the aid of USGS specialists. As a result of this review, a project proposal was prepared to evaluate the possibility of subsurface waste migration at the burial ground.

Several wells on and near NRTS were deepened by the U.S. Bureau of Reclamation. USGS provided geophysical logging and other hydrologic data. The hydraulic heads in the deeper zones in the Snake Plain aquifer are being studied and their effects on disposed wastes being evaluated.

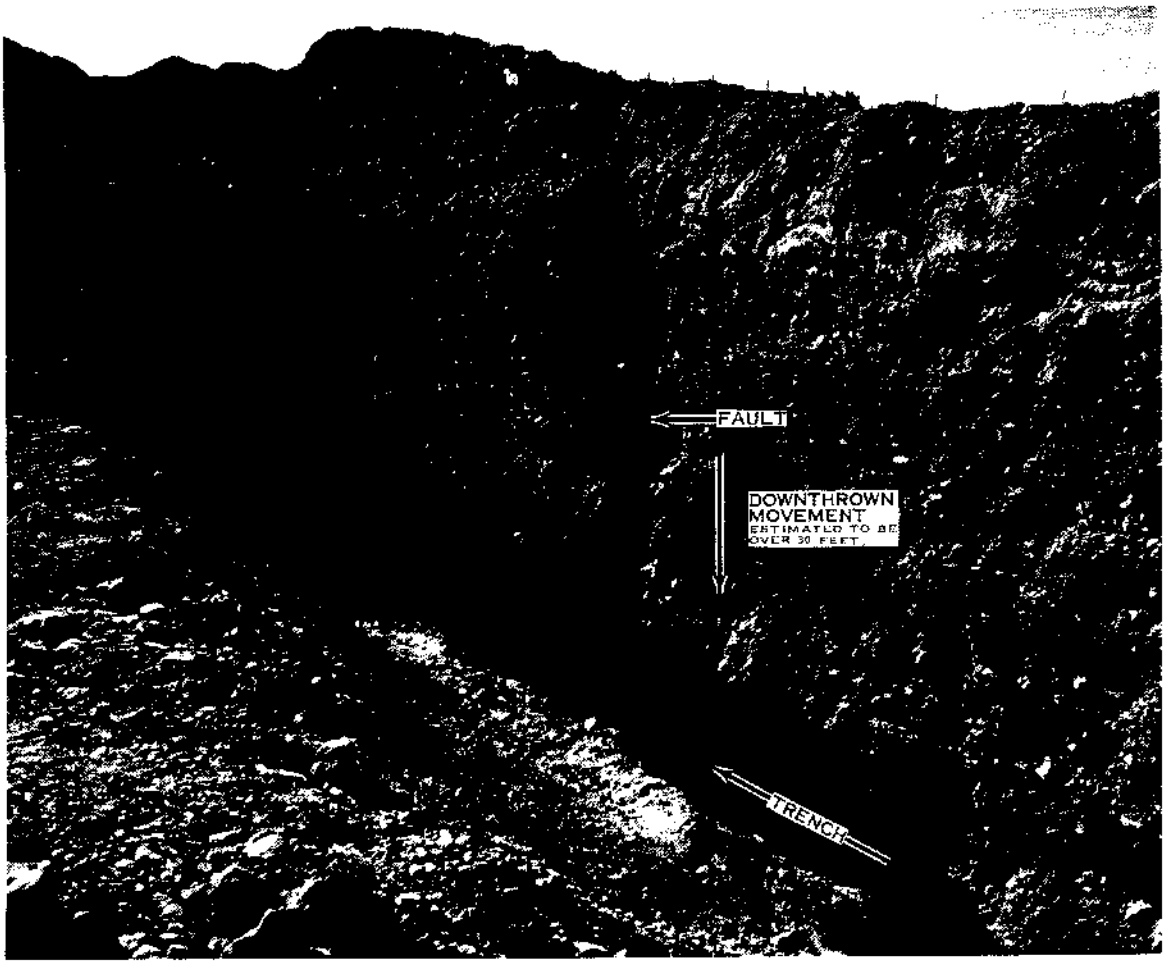
2.2 Catastrophic Floods at NRTS

A systems analysis of flood problems at the NRTS is being prepared by P. H. Carrigan, USGS, Washington, D. C. Flood frequency relations were developed for the Big Lost and Little Lost Rivers and Birch Creek. A digital computer model has been completed for routing flows through various river sections. The analysis is intended to predict the magnitudes of very rare catastrophic floods and their possible effects on the NRTS.

2.3 Seismic Investigations at NRTS

A study was completed by H. E. Malde, USGS, Denver, Colorado to determine the potential for faulting and earthquakes at or near the NRTS. Lineaments and linear features on the NRTS were excavated to the underlying basalt. The study indicated that the lineaments are not a result of faulting. Clay Butte, north of Mud Lake, was drilled to determine if it had been faulted, but no faulting was detected at this location. Two scarps, one north of Arco (see Figure 13) and another north of Howe, were excavated. The huge excavations revealed faulting at both locations.

Six telemeter seismometers were installed by the USGS National Center for Earthquake Research. The data from these stations were transmitted to Menlo Park, California for eight months. The instruments indicated that the NRTS is a very quiet seismic area. The earthquake study is now completed and the final report is being reviewed.



EXCAVATION NORTH OF ARCO SHOWING FAULTING IN GRAVELS. THE LENGTH AND DISPLACEMENT OF THE FAULT SUGGEST THE INTENSITY OF THE ASSOCIATED EARTHQUAKE. THIS INFORMATION IS USEFUL IN REACTOR DESIGN SPECIFICATIONS.

Fig. 13 Fault in excavation north of Arco, Idaho.

3. PUBLICATIONS

R. D. Lamke, Stage-Discharge Relations on Big Lost River Within National Reactor Testing Station, Idaho , IDO-22050, U. S. Geological Survey open-file report (March 1969).

J. B. Robertson, Behavior of Xenon-133 Gas After Injection Underground: Molecular Diffusion, Materials Balance, and Barometric Pressure Effects , IDO-22051, U. S. Geological Survey open-file report (July 1969).

J. B. Robertson, Diffusion From a Gaseous Source in Porous Media: A Field and Theoretical Comparison, U. S. Geological Survey Professional Paper 650-D, (December 1969).

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

U. S. Department of Commerce

(C. R. Dickson)

1. RESEARCH AND DEVELOPMENT PROJECTS

1.1 Measurement Program Over Los Angeles Basin

The Air Resources Laboratories and the Atmospheric Physics and Chemistry Laboratory of ESSA, with the assistance of numerous local agencies and the Atomic Energy Commission, accomplished a measurement program over the Los Angeles Basin during September and October 1969.

A small radar transponder was developed by the Air Resources Laboratories Field Research Office in Idaho Falls. The system, powered by a small battery, is attached to a tetrahedron-shaped plastic balloon, called a tetroon, and, while flying at a nearly constant height, is interrogated by signals from a tracking radar which is a surplus military unit (M-33) modified by ARLFRO, NRTS, specifically for tetroon tracking research.

In the experiment, 110 tetroons were flown at altitudes of 300 to 500 feet. They were launched both day and night from various locations in the Los Angeles Basin, but primarily from locations along the coast and near downtown Los Angeles. The tetroons were released from a mobile launch truck (a specially equipped moving van) so that they moved with the offshore land breeze at night and with the west and southwest sea breeze during the day.

One of the objectives of the experiment was to determine the detailed structure changes in the low-level air flow as the air moved across the variable terrain and urban development within the Basin. Also, measurements of air quality data along the tetroon path taken by helicopter provided unique data on the change in pollution along the air "parcel" path.

The tetroons were continuously tracked by the M-33 radar, with positions recorded at one-second intervals. On occasion more than one tetroon was tracked by alternately positioning first one, then the other. The radar also vectored the air sampling helicopter to the tetroon location.

A helicopter carrying equipment developed by the Atmospheric Physics and Chemistry Laboratory for measuring oxidant, temperature, pressure, and humidity flew very near the tetroon and took periodic measurements of the changes in these parameters along the path of the air, as depicted by the tetroon. These measurements were made at very frequent intervals. The helicopter also measured the vertical profiles of oxidant, temperature, and humidity from near the surface into the persistent temperature inversion.

1.2 Mesoscale Turbulence and Diffusion Studies

The computational scheme for obtaining the objective analyses of mesoscale flow patterns from randomly spaced wind stations was modified and

improved to be much more versatile and efficient for routine use. The display of the wind field and trajectory plots is now done directly on microfilm. This allows rapid scanning and convenient handling of large quantities of data. It has been found in scanning approximately six months of data that a large circular eddy of about 35 miles in diameter occasionally forms in the upper end of the Snake River Plain and persists for several hours. Preliminary observations indicate that transport of material in the atmosphere near the surface may be very suddenly and severely modified by a downward transport of momentum from the flow above.

1.3 Study of Cloud Removal Processes

Data from 18 field releases of radioiodine gas and environmental chamber experiments collected for the Controlled Environmental Radioiodine Tests (CERT) project were used to summarize our knowledge of transfer processes of radioiodine gas from air to grass. The processes considered were stomatal transfer, grass leaf cuticle adsorption, surface sublayer transport, and surface boundary layer transport. In the surface sublayer, a functional relationship between gas transfer and leaf surface area was found. Stomatal transfer and leaf cuticle adsorptions were found to be important processes affecting the removal of radioiodine gas from the atmosphere.

A study of sampling durations effects on measurements of surface boundary layer turbulence was made. The results of the study show that selection of sampling duration for turbulence computation is very important and that a fundamental understanding of surface boundary layer turbulence processes cannot be achieved unless the three-dimensional character of these atmospheric motions is described.

1.4 Forecast Verification

The complete summary of forecasts of temperature, precipitation, and winds over the period February 1965 through June 1969 was made. Verification statistics of temperatures, precipitation, and winds are being evaluated on twice daily forecasts, which are issued Monday through Friday except holidays.

The objective in the verification is to find weak points and systematic errors that need further study and to furnish comparative forecasts to evaluate the effectiveness of statistical forecast studies. On data gathered thus far, a primary weak point is minimum temperatures in winter.

1.5 Wind Studies

Because a primary concern of the laboratory is the small scale transport of pollutants, the primary objective of forecast research is wind prediction, both at a point and in a region. In the absence of prominent terrain or large water bodies the two scales of prediction (large and small) are probably the difference in winds between random points within the mesoscale region.

The study of wind fields in the upper Snake River Valley, where prominent terrain features do influence the mesoscale wind field, was made.

In addition, the wind fields are being studied from the forecast point of view. They are divided into classes or types of flows, which in turn can be forecast.

1.6 Turbulence Analysis

In order to examine more closely the true response characteristics of the cup anemometer used in conjunction with bi-directional wind vanes in the analyses of velocity fluctuations, an experiment was conducted to obtain data simultaneously from a cup anemometer and a hot wire anemometer for a comparison of the energy spectra.

The overall purpose of this type of work is to determine the representativeness with which electronics and mechanical sensors report the turbulent fluctuations of atmospheric phenomena. It is especially essential that this information be available before extensive experimentation and computation be carried out in studies involving the turbulent transport of sensible heat and momentum, or in studies of the relationship of turbulence to diffusion. Work is currently in progress in which the response characteristics of a thermocouple are being examined under various configurations of exposure to the atmosphere. It appears that the combination of the electronic computer, high speed recording equipment, and the Fast Fourier Transform Technique have shifted a good portion of the burden of responsibility in the study of atmospheric turbulence back to the sensors.

1.7 Sampling Time Effects on Measurements of Surface Boundary Layer Turbulence

The effects of sampling time on measurements of the orthogonal components of surface boundary layer turbulence were examined for sampling intervals of 1, 3, 6, 9, 15, 30, and 60 minutes. Eighty-four hours of 2-sec, digitally-sampled bivane and cup anemometer data from the 16-m level of the Grid III tower were used for the analysis. These hourly data were obtained from semicontinuous records collected during the summer of 1968. Most of the data were collected during nighttime conditions. Average values of u'^2, v'^2, w'^2, $u'\overline{w}'$, $v'\overline{w}'$, and $u'\overline{v}'$ were computed for each of the sampling intervals within each one-hour period. These turbulence parameters were then stratified into atmospheric stability regimes by Richardson number, Ri, (Slade, 1968) calculated from wind speeds and temperature at the 8 and 32 m levels.

Some of the significant findings from this study follow: (a) The longitudinal (u) and lateral (v) velocity variance ratios show a significantly large variation with sampling interval, while the vertical (w) velocity variance shows only a small variation. (b)Thermally driven turbulence is a separate and distinct contributor to lateral velocity variance during unstable conditions as evidenced by inflection points in the curves between the 6 and 15 minute sampling intervals. (c) Undulations in the longitudinal and lateral component velocities produce contributions to their respective variances for sampling intervals greater than six minutes.

The results of this study show that the selection of sampling interval for turbulence computations is very important. Instantaneous deviations from vector mean velocities determined from sampling intervals less than six minutes seem to represent mechanical turbulence. Most of the turbulent energy

created by thermal convection appears to be contained between frequencies with periods from 6 to 15 minutes. During stable atmospheric conditions, atmospheric undulations become important contributors to component velocity variance at frequencies with periods from 6 to greater than 60 minutes. The results of this study also indicate that a fundamental understanding of surface boundary layer turbulence processes cannot be achieved unless the three-dimensional character of these motions is studied.

1.8 Mesoscale Diffusion

Calculated total integrated concentration (TIC) values obtained from the mesoscale transport and puff diffusion model were compared to measured values sampled over the upper Snake River Plain. A part of this comparison was an examination of the puff diffusion estimates versus estimates from the Gaussian diffusion equation for a continuous point source.

To evaluate the model, measured one-week integrated effluent concentrations were obtained for several points over the upper Snake River Plain. The effluent source was assumed to be the 250-foot stack at the Chemical Processing Plant located three miles to the north of the Central Facilities Area (CFA). Hypothetical particles were released, during each week, at the rate of one per hour and transported in the hourly averaged wind fields. Each individual trajectory was traced for 23 hours or until it left the computational area, whichever was the shorter. The trajectories are numbered sequentially for each consecutive 12-hour period during the week and letter symbols are located at one-hour intervals along each trajectory.

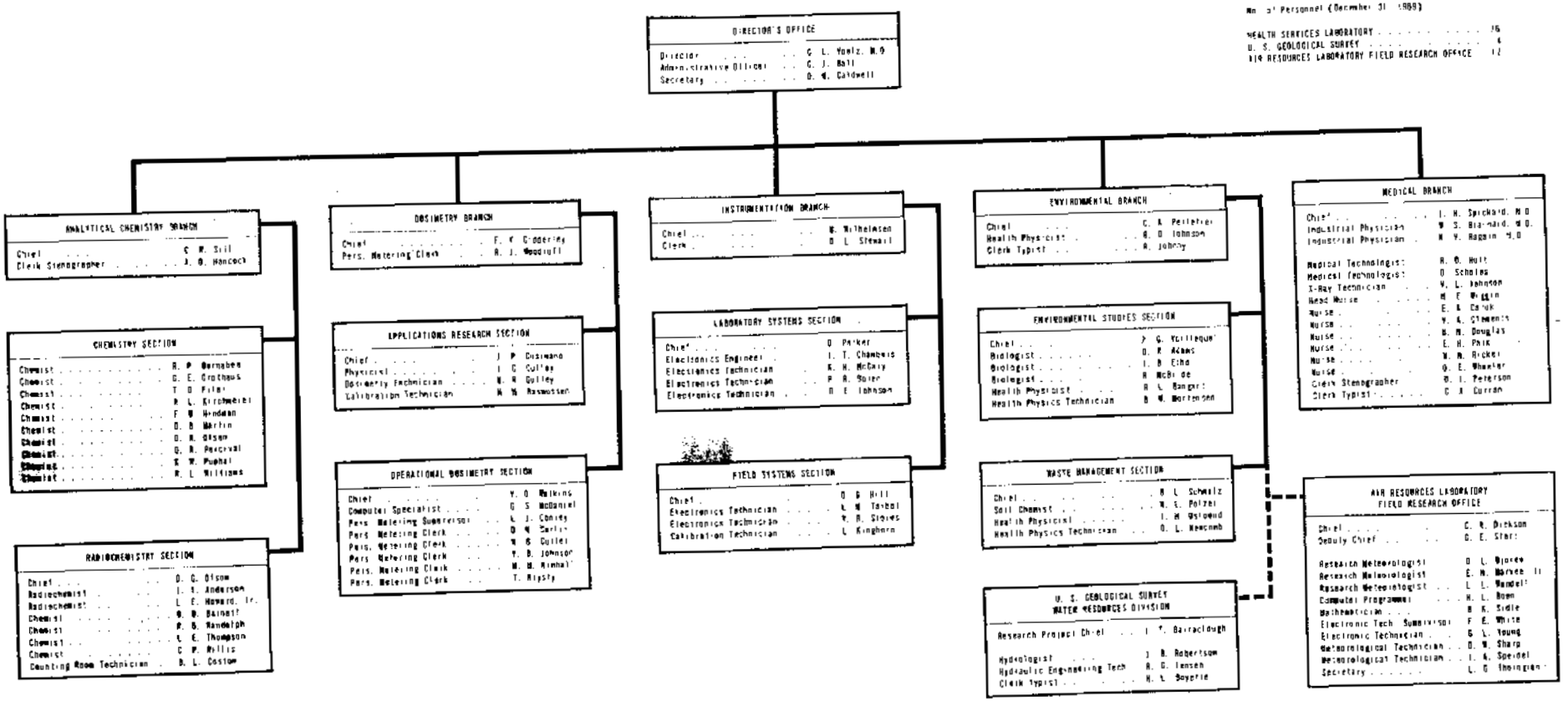
2. PUBLICATION

E. H. Markee, Jr., and D. R. Adams, "Some Processes Affecting the Transfer of Radioiodine Gas from Air to Grass", submitted for publication in Atmospheric Environment (1970).

INTENTIONAL BLANK PAGE NO. 50

APPENDIX - - ORGANIZATIONAL CHART OF THE HEALTH SERVICES LABORATORY

HEALTH SERVICES LABORATORY



ERRATUM FOR IDO-17299

INSTRUMENT DEVELOPMENT BRANCH

ANNUAL REPORT 1968

Page 93, Figure 64:

Please substitute the illustration on this page for the one printed on page 93 (the caption is correct as printed).